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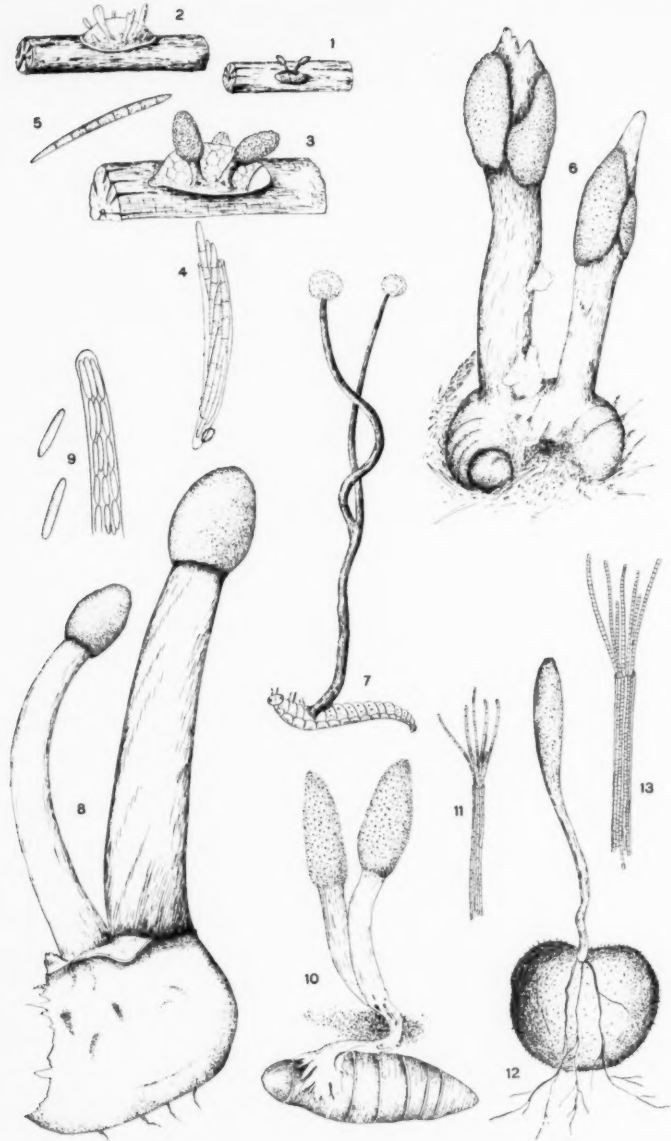
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CORDYCEPS

MYCOLOGIA

VOL. III

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No. 5

THE HYPOCREALES OF NORTH AMERICA—IV

Tribe IV. CORDYCEPITEAE

FRED J. SEAVER

(WITH PLATES 53 AND 54, CONTAINING 26 FIGURES)

Sclerotia formed in the bodies of insects or in the stems of plants, consisting of a more or less well-developed, often compact and hard mycelial tissue; stromata developing from the sclerotia usually after a period of rest, erect and clavate or rarely pulvinate; perithecia immersed or subsuperficial (especially in aged specimens); asci cylindric; spores filiform or subfiliform, simple or many-septate, often breaking into numerous segments, hyaline.

Sclerotia formed in the bodies of insects or fruiting organs of fungi.

36. CORDYCEPS.

Sclerotia formed in the tissues of vascular plants.

Sclerotia originating in the ovaries of plants; stromata long-stipitate.

37. SPERMOEDIA.

Sclerotia formed in the stems or fruiting axes of plants; stromata short-stipitate or sessile.

38. BALANSIA.

36. CORDYCEPS (Fries) Link, Handb. 3: 347. 1833

Sphaeria §*Cordyceps* Fries, Syst. Myc. 2: 323. 1823.

Torrubia Lev.; Tul. Fung. Carp. 3: 5. 1865.

Stromata springing from the sclerotium or resting stage of the fungus composed usually of compact mycelial tissue within the bodies of insects or more rarely in other fungi, simple or branched,

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at first (*Isaria* stage) often delicate, producing conidia, later usually clavate, producing perithecia, which are more or less immersed or more rarely subsuperficial, collected into a globose, clavate, or agariciform head supported by a sterile stem, or sometimes surmounted by a sterile apex; asci cylindric, 8-spored; spores filiform or subfiliform, many-septate and often breaking into segments in the ascus, or more rarely simple and entire.

Type species, *Clavaria militaris* L.

Sclerotia formed in the bodies of insects or larvae.

Perithecia collected into a definite, enlarged head, usually immersed.

Stromata large, several cm. high.

Occurring on larvae or pupae.

Head fertile to the tip.

Head clavate.

Stromata bright-orange; on pupae.

1. *C. militaris*.

Stromata brownish; on larvae.

Spore segments short, 1.5 mic. in length.

2. *C. palustris*.

Spore segments long, 3-5 mic. in length.

Plants stout; spore segments 4-5 mic. in length.

3. *C. Ravenelii*.

Plants slender; spore segments 3.5 mic. in length.

4. *C. acicularis*.

Head globose or subglobose.

Plants purplish.

5. *C. insignis*.

Plants yellowish.

Spore segments 4 mic. in length.

6. *C. flavella*.

Spore segments 6-8 mic. in length.

7. *C. entomorrhiza*.

Head with a sterile apex.

Plants stout, yellowish; on white grubs.

8. *C. herculea*.

Plants slender, brownish; on larvae.

9. *C. stylophora*.

Occurring on adult insects (wasps).

10. *C. sphecocephala*.

Stromata small, less than 1 cm. high.

Spores much shorter than the ascus, fusoid; on scale-insects.

11. *C. clavulata*.

Spores nearly as long as the ascus, filiform; not on scale-insects.

Plants 3 mm. high, reddish-purple.

12. *C. Langloisii*.

Plants 5-9 mm. high, yellowish.

13. *C. armeniaca*.

- Perithecia scattered, becoming subsuperficial.
 Stromata very long and slender, 5 cm. high. 14. *C. Sphingum*.
 Stromata 1 cm. or less high.
 Stromata effuse or erect; perithecia becoming spatulate when dry. 15. *C. Cockerellii*.
 Stromata erect; perithecia flask-shaped. 16. *C. isarioides*.
 Sclerotia formed in fungi.
 Stromata agariciform. 17. *C. agariciformia*.
 Stromata clavate. 18. *C. parasitica*.

I. CORDYCEPS MILITARIS (L.) Link, Handbk. 3: 347. 1833

Clavaria militaris L. Sp. Pl. 1182. 1753.

Ramaria farinosa Holmsk. Danske Vid-Selsk. Skr. II. 1: 299. 1781.

Clavaria granulosa Bull. Herb. Fr. pl. 496, f. 1. 1790.

Clavaria farinosa Dicks. Pl. Crypt. Brit. 2: 25. 1790.

Isaria farinosa Fries, Syst. Myc. 3: 271. 1832.

Kentrosporium militare Wallr. Beitr. Bot. 166. 1844.

Torrubia militaris Tul. Fung. Carp. 3: 6. 1865.

Sclerotia formed in the pupae of insects, compact, white; conical stage (*Isaria*) rising from the sclerotium, consisting of a slender stalk, and a white, floccose, feather-like head; stromata at maturity consisting of a sterile stem and fertile, clavate head, usually simple but more rarely forked or branched, the whole often attaining a height of 4-5 cm., but often much shorter, bright-orange; perithecia thickly scattered or crowded, for the most part immersed with the necks protruding, or superficial (especially in weathered specimens); asci cylindric; spores filiform, nearly as long as the ascus, many-septate, breaking apart at the septa, giving rise to numerous subellipsoid segments 2-3 mic. long (pl. 53, f. 10, 11).

On pupae buried or partially buried in the ground.

TYPE LOCALITY: Europe.

DISTRIBUTION: Massachusetts to North Dakota and Virginia; also in Europe.

ILLUSTRATIONS: Bull. Herb. Fr. pl. 496, f. 1; Fl. Dan. pl. 657, f. 1; Sow. Engl. Fungi pl. 60; pl. 308.

SPECIMENS EXAMINED: Connecticut, Earle; Iowa, Seaver; Massachusetts, Morris; North Dakota, Seaver (*Isaria* stage only); New York, Murrill, Seaver; New Jersey, Ellis; Pennsylvania, Small; Vermont, Burlingham; Virginia, Murrill.

2. *CORDYCEPS PALUSTRIS* Berk & Br.; Berk. Jour. Linn.

Soc. 1: 159. 1857

Stromata 1-3 cm. high; stem 3-4 mm. thick, simple or divided into 2-4 short branchlets, even, smooth, brown; head 1-2 cm. long, thicker than the stem, cylindric-ovoid, dull brownish-purple or flesh-colored, minutely rough with the slightly protruding necks of the perithecia; asci elongate, narrowly cylindric, capitate, tapering below into a long, slender pedicel; spores arranged in a parallel fascicle, slightly curved, filiform, hyaline, becoming many septate, $100-120 \times 1$ mic., the segments 1.5 mic. long (*pl. 54, f. 5*).

On moist rotten logs, growing from the larvae of some coleopterous insect.

TYPE LOCALITY: South Carolina.

DISTRIBUTION: Known only from the type locality.

ILLUSTRATION: Jour. Linn. Soc. 1: *pl. 1*.

Berkeley in his original description of this species says: "The extremely minute articulations or sporidiola, without any other character, separate this curious species which has moreover a peculiar habit."

3. *CORDYCEPS RAVENELII* Berk. & Curt.; Berk. Jour. Linn. Soc.

1: 159. 1857

Stromata usually solitary, 3-8 cm. high, consisting of a sterile stem and fertile head; stem 2-5 cm. long, grooved or furrowed, brownish, becoming nearly black on drying, about 2-3 mm. in diameter; fertile head terminal or more rarely with a sterile apex, or with the perithecia in patches, with bare, sterile spaces between; perithecia partially immersed, becoming almost entirely superficial, giving the fertile portions a very rough appearance, similar in color to the stem; asci very long, cylindric; spores filiform, nearly as long as the ascus, breaking into segments 4-5 mic. long (*pl. 54, f. 10*).

Springing from the larvae of coleopterous insects.

TYPE LOCALITY: South Carolina.

DISTRIBUTION: South Carolina to Pennsylvania (and Iowa?).

ENSICCATI: Rav. Fungi Car. 4: 28. Other specimens examined: Pennsylvania, *Everhart*.

According to Masee, this species has been collected in Texas by Wright, also in California by Harkness and is known in the western states as the "white grub fungus." While the species

seems to have been frequently collected but few specimens are available for examination.

4. CORDYCEPS ACICULARIS Rav.; Berk. Jour. Linn. Soc. 1: 158.
1857

? *Torrubia Melolonthae* Tul. Fung Carp. 3: 12. 1865.

? *Torrubia superficialis* Peck, Ann. Rep. N. Y. State Mus. 28: 70.
1857.

? *Cordyceps Melolonthae* Sacc. Michelia 1: 320. 1878.

Stem simple, elongate, slender, cylindric, often flexuous, brownish, minutely velvety at the base, smooth above, 5-8 cm. high and 1.5 mm. thick; head cylindric, about 1.5 cm. long and 3 mm. thick; perithecia blackish, large, ovoid, subsuperficial; asci subcylindric, capitate at the apex, with a short pedicel below; spores arranged in a parallel fascicle in the ascus, hyaline, filiform, straight or curved, many-septate, 130×2.5 mic.; segments 3.5 mic. long (pl. 54, f. 9).

On larvae buried in the ground.

TYPE LOCALITY: South Carolina.

DISTRIBUTION: South Carolina (and New York?).

ILLUSTRATIONS: Jour. Linn. Soc. 1: pl. 1; Ann. Bot. 9: pl. 2, f. 27, 28.

EXSICCATI: Rav. Fungi Car. 4: 29 (as *Cordyceps carolinensis* Berk. & Rav.).

Berkeley says: "This species is closely allied to *C. Ravenelii* but the habit is very different. I can find no essential difference in the fruit."

Massee also regards *C. Ravenelii* as scarcely more than a variety of the present species.

Mr. Peck (l. c.) states that *T. superficialis* is "related to and intermediate between *T. Ravenelii* and *T. carolinensis*." It is not unlikely that a more extended study will show the three species to be identical.

5. CORDYCEPS INSIGNIS Cooke & Rav.; Cooke, Grevillea 12: 38.
1883

Stromata 4-6 cm. long, purple; stem 7-8 mm. thick, equal, pallid, sulcate (when dry), very minutely velvety at the base; head broadly ovoid, 1.5 cm. in length, very slightly roughened by the

necks of the slightly protruding perithecia; asci narrowly cylindric, slightly constricted below the capitate apex, narrowed below into a slender stem-like base; spores arranged in a parallel fascicle, slightly twisted, hyaline, filiform, many-septate, wavy when free, $170-180 \times 15$ mic., separating readily into segments in the ascus; segments 6-7 mic. long.

On larvae on the ground.

TYPE LOCALITY: South Carolina.

DISTRIBUTION: Known only from the type locality.

6. *CORDYCEPS FLAVELLA* Berk. & Curt.; Berk. Jour. Linn. Soc.

10: 375. 1868

Stromata gregarious, 3-5 springing from nearly the same point; stem 2.5-3 cm. long, about 1 mm. thick, straight or more or less curved or flexuous, even and smooth; head globose, roughened by the necks of the protruding perithecia, 2 mm. in diameter, similar in color to the stem; asci elongate, narrowly cylindric, capitate at the apex, narrowed below into a slender pedicel; spores arranged in a fascicle, filiform, many-septate, 80×1 mic.; component cells about 4 mic. long.

Growing from a caterpillar.

TYPE LOCALITY: Cuba.

DISTRIBUTION: Cuba.

ILLUSTRATIONS: Ann. Bot. 9: pl. 2, f. 7-10.

7. *CORDYCEPS ENTOMORRHIZA* (Dicks.) Link, Handbk. 3: 347.

1833

Sphaeria entomorrhiza Dicks. Pl. Crypt. Brit. 1: 22. 1785.

Xylaria gracilis Grev. Scot. Crypt. Fl. pl. 86. 1823.

Torrubia entomorrhiza Tul. Fung. Carp. 3: 14. 1865.

Cordyceps Menesteridis Muell. & Berk.; Berk. Gard. Chron. II.

10: 791. 1878.

Stromata consisting of a sterile stem and a subglobose fertile head; stem very slender, 2-8 cm. long, yellowish; head $5-8 \times 4$ mm., golden-yellow, darker with age, roughened by the prominent necks of the perithecia; perithecia ovoid, immersed or partially immersed; asci cylindric, 6.5-7 mic. thick; spores filiform, many-septate, hyaline, finally separating into segments 6-8 mic. long (pl. 53, f. 7).

On larvae of insects.

TYPE LOCALITY: Europe.

DISTRIBUTION: South Carolina; also in Europe, Asia, Africa, and Australia.

ILLUSTRATIONS: Dicks. Pl. Crypt. Brit. *pl.* 3, *f.* 3; Gard. Chron. II. 10: 791, *f.* 130; Tul. Fung. Carp. 3: *pl.* 1, *f.* 12-14; Grev. Scot. Crypt. Fl. *pl.* 86.

8. CORDYCEPS HERCULEA (Schw.) Sacc. Syll. Fung. 2: 577. 1883.

Sphaeria herculea Schw. Trans. Am. Phil. Soc. II. 4: 188. 1832.

Stromata large, attaining a height of 5-7 cm.; stem yellowish or tan-colored; head enlarged and more than 1 cm. thick, with the fertile portion often interrupted, leaving bare patches and in the specimens examined terminated by a short, obtuse apex; fertile portion roughened by the slightly prominent necks of the perithecia; asci cylindric, as long as 200-225 mic.; spores filiform, nearly as long as the ascus, many-septate, separating into joints 6-8 mic. (*pl.* 53, *f.* 6).

On larvae (white grubs).

TYPE LOCALITY: Salem, North Carolina.

DISTRIBUTION: Connecticut to Ohio and North Carolina.

SPECIMENS EXAMINED: Ohio, *Morgan*; Georgetown, D. C., *Billings*.

9. CORDYCEPS STYLOPHORA Berk. & Br.; Berk. Jour. Linn. Soc.

1: 158. 1857

Stromata solitary, dull-brownish, consisting of a sterile stem and fertile head, with a long sterile apiculus, the entire plant 2-3 cm. high; stem straight or flexuous, more or less velvety, longitudinally wrinkled when dry; fertile head slightly roughened by the protruding perithecia; sterile apiculus 1 cm. or more long, asci cylindric or slightly constricted below the capitate apex; spores arranged in a fascicle, filiform, curved when free, many-septate, $125-135 \times 1$ mic.; segments 3.5 mic. long (*pl.* 54, *f.* 1).

On larvae in rotten logs.

TYPE LOCALITY: South Carolina.

DISTRIBUTION: Michigan and South Carolina.

ILLUSTRATIONS: Jour. Linn. Soc. 1: *pl.* 1; Ann. Bot. 9: *pl.* 2, *f.* 40-42.

EXSICCATI: Rav. Fungi Car. 5: 49.

10. CORDYCEPS SPHECOCEPHALA (Klotzsch) Masee, Ann. Bot.

9: 13. 1895

Sphaeria sphecocephala Klotzsch; Berk. Lond. Jour. Bot. 2: 206. 1843.

Torrubia sphecocephala Tul. Fung. Carp. 3: 18. 1865.

Cordyceps sphecocephala Berk. & Curt.; Berk. Jour. Linn. Soc. 10: 376. 1868.

Stromata 2-5 cm. high, consisting of a slender, sterile stem and a fertile head; stem pale-yellow, fibrous, often slightly twisted, 0.5-1 mm. thick; head enlarged, clavate, 5-8 mm. in length and 1.5-2 mm. in thickness, roughened by the slightly protruding necks of the perithecia; perithecia immersed, scattered, prominent; asci very long, cylindric; spores nearly as long as the ascus, breaking into fusoid segments 9-10 mic. long (*pl. 51, f. 3-4*).

Springing from the bodies of wasps.

TYPE LOCALITY: Jamaica.

DISTRIBUTION: West Indies.

ILLUSTRATIONS: Tul. Fung. Carp. 3: *pl. 1, f. 5-9*.

SPECIMENS EXAMINED: Cuba (specimen given by *Mel. T. Cook*); also collected by *N. L. Britton* and *Percy Wilson*.

11. CORDYCEPS CLAVULATA Schw. Trans. Am. Phil. Soc. II.

4: 188. 1832

Cordyceps pistillariaeformis Berk. & Br. Ann. Mag. Nat. Hist.

III. 7: 451. 1861.

Torrubia pistillariaeformis Cooke, Handbk. Brit. Fungi 771. 1871.

Torrubia clavulata Peck, Ann. Rep. N. Y. State Mus. 28: 70. 1876.

Sclerotia formed in the bodies of dead scale-insects; stromata slender, clavate, at first sterile, at maturity with an enlarged, clavate, fertile head and a slender, sterile stem, the whole 3-4 mm. high, 3-8 springing from a single sclerotium; stem slender, 1-2 mm. long, grayish or cinereous; head thicker, darker in color and strongly roughened by the protruding necks of the perithecia; asci clavate, broader near the middle, 80-100 \times 8-10 mic.; spores much elongate, subfiliform, broader near the base and tapering toward either end, 7-8-septate about 50-80 mic. long, 3 mic. thick at the broadest point, hyaline (*pl. 53, f. 1-5*).

On dead scale-insects on the branches of various kinds of trees and shrubs.

TYPE LOCALITY: Bethlehem, Pennsylvania.

DISTRIBUTION: New York and New Jersey to North Dakota.

ILLUSTRATIONS: Ann. Mag. Nat. Hist. III. 7: *pl. 16, f. a-c*;

Ellis & Everh. N. Am. Pyrenom. *pl. 15, f. 11-13*.

EXSICCATI: Ellis & Everh. N. Am. Fungi 2814. Other specimens examined: Delaware, *Commons*; New York, *Peck*; North Dakota, *Seaver*; Ontario, *Dearness*.

12. CORDYCEPS LANGLOISII Ellis & Everh. N. Am. Pyrenom. 62.
1892

Stromata solitary, simple, consisting of a sterile stem and a subglobose head, the entire plant about 3 mm. high; stem 1 mm. thick, cylindric or subcompressed; head capitate, at first white, becoming reddish-purple, the upper convex surface fertile; perithecia tough-membranaceous, ovoid-conic, $100-150 \times 200-300$ mic., partially immersed in the stroma; asci very long, subcylindric; spores filiform, interwoven, nearly as long as the ascus, less than 0.5 mic. thick.

On dead larvae of the mason wasp.

TYPE LOCALITY: St. Martinsville, Louisiana.

DISTRIBUTION: Known only from the type locality.

SPECIMENS EXAMINED: Louisiana, *Langlois* (type).

13. CORDYCEPS ARMENIACA Berk. & Curt.; Berk. Jour. Linn. Soc.
1: 158. 1857

Stromata solitary or 2 or 3 springing from nearly the same point, 5-9 mm. high, consisting of a sterile stem and a fertile head; stem about 1 mm. thick, often flexuous and twisted, pale orange with a tinge of pink; head subglobose, 2-3 mm. in diameter, apricot-colored, roughened by the slightly protruding necks of the perithecia; asci long, cylindric-clavate, capitate, with a slender pedicel below; spores in a fascicle, slightly curved when free, filiform, becoming many-septate, $80-85 \times 1$ mic., breaking into segments 3 mic. long (*pl. 54, f. 2*).

On the excrement of birds (probably containing insect remains).

TYPE LOCALITY: South Carolina.

DISTRIBUTION: South Carolina.

ILLUSTRATIONS: Jour. Linn. Soc. 1: *pl. 1, f. 1*; Ann. Bot. 9: *pl. 2, f. 18*.

14. *CORDYCEPS SPHINGUM* (Schw.) Berk. & Curt.; Berk. Jour. Linn. Soc. 10: 375. 1868

Isaria Sphingum Schw. Schr. Nat. Ges. Leipzig 1: 126. 1822.

Torrubia Sphingum Tul. Fung. Carp. 3: 12. 1865.

Stromata numerous, as many as thirty often springing from a single sclerotium, very slender and thread-like, about 5 cm. high and 1 mm. in thickness, cinereous, smooth or slightly pruinose, enlarged at the base, more or less bent above; perithecia subsuperficial, subconic, $125-150 \times 200-225$ mic., brownish; asci elongate, cylindric; spores filiform, as long as the ascus, about 2 mic. thick (*pl. 54, f. 11*).

On dead larvae in cocoon.

TYPE LOCALITY: North Carolina.

DISTRIBUTION: New Jersey to North Carolina.

ILLUSTRATIONS: Ellis & Everh. N. Am. Pyrenom. *pl. 15, f. 4-7*; Tul. Fung. Carp 3: *pl. 1, f. 1, 2*.

SPECIMENS EXAMINED: New Jersey, *Ellis*.

15. *CORDYCEPS COCKERELLII* (Ellis & Everh.) Ellis; Cockerell, Jour. Inst. Jamaica 1: 180. 1893

Ophionectria Cockerellii Ellis & Everh.; Ellis, Jour. Inst. Jamaica 1: 141. 1892.

Stromata effuse, spreading over and almost covering the substratum, or erect and 1-2 mm. high, yellow; perithecia occurring in cespitose rounded or irregular clusters, or scattered, subsuperficial or nestling in the substratum; individual perithecia elongate, flask-shaped or cylindric, about 1 mm. high and 0.5 mm. in diameter, reddish-brown or slightly translucent, smooth, at maturity collapsing laterally, becoming spathulate in form; asci very slender, about 1 mic. thick, breaking up into short segments (*pl. 54, f. 6-8*).

On the body of a sphingid moth.

TYPE LOCALITY: Jamaica.

DISTRIBUTION: Jamaica.

SPECIMENS EXAMINED: Bath, Jamaica, *Mrs. Swainson* (Type).

This species, which is said by Professor Cockerell to occur on a sphingid moth, is similar in perithecial and spore characters to *C. Sphingum*. The stromata in this species, however, are effuse or very short while in *C. Sphingum* they are very long and slender. This may be only a variation of the former species.

16. *CORDYCEPS ISARIOIDES* M. A. Curtis.; Masee, Ann. Bot. 9:
36. 1895

Stromata gregarious, springing from a dense, white mycelium which almost entirely covers the host, 4-8 mm. high, about 1.5 mm. thick, cylindric, almost smooth, even, ochraceous (when dry), sometimes slightly curved; fertile portion 3-6 mm. long, cylindric, obtuse, axial portion not thicker than the stem; perithecia subsuperficial, large, flask-shaped, with elongate necks, ochraceous, crowded, spreading on all sides at right angles to the axis; asci narrowly cylindric slightly capitate, the base narrowed into a slender pedicel; spores filiform, continuous, flexuous when free, hyaline, $125-135 \times 1.5$ mic., arranged in a parallel fascicle in the ascus (pl. 54, f. 12).

Growing from the remains of a moth.

TYPE LOCALITY: United States.

DISTRIBUTION: Known only from the type locality.

ILLUSTRATIONS: Ann. Bot. 9: pl. 2, f. 36-39.

17. *CORDYCEPS AGARICIFORMIA* (Bolt.) Seaver, N. Am. Fl. 3:
53. 1910

Sphaeria agariciformia Bolt. Hist. Fung. 130. 1789.

Clavaria capitata Holmsk. Topsv. 38. 1790.

Cordyceps capitata Link, Handbk. 3: 347. 1833.

Torrubia capitata Tul. Fung. Carp. 3: 22. 1865.

Cordyceps canadensis Ellis. & Everh. Bull. Torrey Club 25: 501.
1898.

Cordyceps nigriceps Peck, Bull. Torrey Club 27: 21. 1900.

Stromata occurring singly or in clusters of several each, 3-8 cm. high, consisting of a sterile stem and an ovoid or capitate, fertile head; stem uniform in thickness or a little thicker below, fibrous, yellowish, becoming nearly black (in dried specimens), smooth; head ovoid or agariciform, about 1 cm. in diameter, reddish-brown, becoming nearly black, roughened by the slightly protruding necks of the perithecia; perithecia immersed, but prominent; asci very long, cylindric, about 15 mic. thick; spores filiform, nearly as long as the ascus, finally breaking into segments, subhyaline, fusoid or oblong-ellipsoid, with the ends rounded, $20-40 \times 4-5$ mic.

Parasitic on *Scleroderma* (?) and *Elaphomyces*.

TYPE LOCALITY: England.

DISTRIBUTION: Maine to Ontario and Florida.

ILLUSTRATIONS: Bolt. Hist. Fung. *pl.* 130; Tul. Fung. Carp. 3: *pl.* 2, *f.* 10-15; Pers. Myc. Eur. 1: *pl.* 10, *f.* 1-3.

EXSICCATI: Rav. Fungi Am. 387; Rav. Fungi Car. 5: 48. Other specimens examined: Delaware, *Commons*; Florida, *Calkins*; Maine, *Miss White*; Massachusetts, *Britton*; New Jersey, *Ellis*.

18. CORDYCEPS PARASITICA (Willd.) Seaver, N. Am. Fl. 3:

53. 1910

Clavaria parasitica Willd. Fl. Berol. 405. 1787.

Clavaria radicata Bull. Herb. Fr. *pl.* 440, *f.* 2. 1789.

Sphaeria ophioglossoides Ehrh.; Pers. in Holmsk. Coryph. 144. 1797.

Sphaeria radicata DC. Fl. Fr. 2: 283. 1805.

Cordyceps ophioglossoides Link, Handb. 3: 347. 1833.

Torrubia ophioglossoides Tul. Fung. Carp. 3: 20. 1865.

Stromata solitary or very rarely cespitose, consisting of a slender, sterile stem and an enlarged, clavate, fertile head; stem olivaceous, longitudinally striate, becoming very dark colored in dried specimens, sending out numerous branching root-like fibers which surround the substratum and extend for some distance into the surrounding soil; head clavate, much enlarged, tapering often both above and below, dark-brown, becoming nearly black on drying and roughened by the protruding perithecia; perithecia thickly scattered, immersed or slightly protruding; asci very long, often 300 mic., and 8-10 mic. in diameter; spores filiform, nearly as long as the ascus, many-septate and often breaking into segments; segments short, a little longer than broad, about $3-4 \times 2-3$ mic. (*pl.* 53, *f.* 12-13).

On species of *Elaphomyces*.

TYPE LOCALITY: Europe.

DISTRIBUTION: Ontario to Rhode Island and Virginia; also in Europe.

ILLUSTRATIONS: Willd. Fl. Berol. *pl.* 7, *f.* 17; Bull. Herb. Fr. *pl.* 440, *f.* 2.

SPECIMENS EXAMINED: Maine, *Harvey*; New Jersey, *Ellis*; New York, *Underwood*; Ontario, *Dearness*; Pennsylvania, *Haines*, *Everhart & Jefferies*; Rhode Island, *Farlow*; Virginia, *Murrill*.

DOUBTFUL SPECIES

Cordyceps albella Masee, Ann. Bot. 9: 39. 1895. The species was based on imperfectly developed material.

Cordyceps albida Berk. & Curt.; Cooke, Grevillea 12: 78. 1884. On crickets in Cuba. Mr. Cooke states: "Too imperfectly developed for description."

Cordyceps caloceroides Berk. & Curt.; Berk. Jour. Linn. Soc. 10: 375. 1868.

Cordyceps Cicadae (Miq.) Masee, Ann. Bot. 9: 38. 1895. *Isaria Cicadae* Miq. Bull. Sci. Phys. Nat. Néerl. 1838: 85. 1838. *Torrubia Miquelii* Tul. Fung. Carp. 3: 11. 1865. *Cordyceps Miquelii* Sacc. Michelia 1: 320. 1878. This species, which occurs on the larvae of *Cicada*, has been reported as occurring in the United States.

Cordyceps sobolifera (Hill.) Sacc. Michelia 1: 321. 1878. *Clavaria sobolifera* Hill.; W. Wats. Phil. Trans. 53: 271. 1764. *Torrubia sobolifera* Tul. Fung. Carp. 3: 10. 1865. *Sphaeria sobolifera* Berk. Lond. Jour. Bot. 2: 207. 1843. On larvae of *Cicada*. Masee reports this species as occurring in the West Indies (pl. 54, f. 13).

37. SPERMOEDIA Fries, Syst. Myc. 2: 268. 1822

Sphacelia Lév. Mem. Soc. Linn. Paris 5: 578. 1827.

Kentrosporium Wallr. Beitr. Bot. 163. 1844.

Claviceps L. Tul. Compt. Rend. Acad. Sci. Paris 33: 646. 1851.

Sclerotia formed in the inflorescence of various grasses and sedges, at first consisted of a soft mass of mycelium which produces conidia often accompanied with a saccharine fluid, at maturity hard, subglobose subcylindric or horn-shaped, purplish-black externally, white within; stromata developing from sclerotium after a period of rest, consisting of a sterile stem and fertile head; head subglobose, grayish, reddish-brown, or yellowish margin often partially free; perithecia flask-shaped, immersed in the stroma or with the necks slightly protruding; asci cylindric, usually capitate, 8-spored; spores filiform, nearly as long as the ascus simple, hyaline.

Type species: *Sclerotium Clavus* DC.

Little is known of the species of this genus. The following is a list of those which have been recognized for North America.

Sclerotia subcylindric, horn-shaped, or clavate.

Sclerotia in the inflorescence of grasses.

Sclerotia purplish-black.

Sclerotia large, 1-2 cm. long.

1. *S. Clavus*.

Sclerotia small, not more than 5 mm. long.

2. *S. microcephala*.

Sclerotia cinereous.

3. *S. cinerea*.

Sclerotia formed in the inflorescence of sedges.

4. *S. nigricans*.

Sclerotia subglobose, or conical.

Occurring on *Paspalum*.

Perithecia 340×119 mic.

5. *S. Stevensii*.

Perithecia 816×225 mic.

6. *S. Rolfsii*.

Occurring on *Tripsacum dactyloides*.

7. *S. Tripsaci*.

I. SPERMOEDIA CLAVUS (DC.) Fries, Syst. Myc. 2: 268. 1822

Sclerotium Clavus DC. Fl. Fr. 6: 115. 1815.

Sphaeria purpurea Fries, Syst. Myc. 2: 325. 1823.

Sphacelia Segetum Lev. Mem. Soc. Linn. Paris 5: 578. 1827.

Claviceps purpurea L. Tul. Ann. Sci. Nat. III. 20: 45. 1853.

Sclerotia formed in the young ovaries of various species of grasses, at first soft and viscid, at maturity hard, purplish-black externally, whitish within, 1-2 cm. long; stromata often as many as 20-30 from a single sclerotium; stem very slender, flexuous or spirally twisted and of a dark-brownish color; head subglobose with the margin partially free, about 1-2 mm. in diameter, reddish-brown in color and roughened by the slightly protruding necks of the perithecia; perithecia entirely immersed or very slightly protruding, flask-shaped, $150-175 \times 200-250$ mic.; asci very long, cylindric, $100-125 \times 4$ mic.

In the inflorescence of rye, and of other wild and cultivated grasses.

TYPE LOCALITY: France.

DISTRIBUTION: New York to Montana and Utah, and probably throughout North America; also in Europe.

ILLUSTRATIONS: Ann. Sci. Nat. III. 20: pl. 1, 2, 3; Rab. Krypt. Fl. 1²: f. 1-5; E. & P. Nat. Pfl. 1¹: f. 247, B-L.

EXSICCATI: Ellis & Everh. Fungi Columb. 1614, 1816, 2216, 1327; D. Griff. W. Am. Fungi 42; Brenckle, Fungi Dak. 4. Other specimens examined: Colorado, Tracy; Kansas, Bartholomew; Montana, Anderson, Kelsey; Ohio, Craig; Wisconsin, Davis, Pammel, T. A. Williams.

2. SPERMOEDIA MICROCEPHALA (Wallr.) Seaver, N. Am. Fl. 3:

55. 1910

Kentrosporium microcephalum Wallr. Beitr. Bot. 164. 1844.*Sphaeria microcephala* Wallr. Beitr. Bot. 164, as syn. 1844.*Claviceps microcephala* L. Tul. Ann. Sci. Nat. III. 20: 49. 1853

Sclerotia not exceeding 5 mm. in length; apparently differing from the preceding species only in the smaller size of the sclerotia and stromata.

In the inflorescence of various grasses; American specimens on *Calamagrostis* seem to conform with descriptions of this species.

TYPE LOCALITY: Europe.

DISTRIBUTION: North Dakota; also in Europe.

ILLUSTRATIONS: Wallr. Beitr. Bot. pl. 3, f. 10-16; Ann. Sci. Nat. III. 20: pl. 4, f. 1-11.

ENSICCATI: Brenckle, Fungi Dak. 4.

3. SPERMOEDIA CINEREA (D. Griff.) Seaver, N. Am. Fl. 3: 55.

1910

Claviceps cinereum D. Griff. Bull. Torrey Club 28: 240. 1901.

Sclerotia clavate, gradually tapering upwards, straight, curved, twisted, or contorted, 1.5-3 cm. long and 1.75-2.5 mm. thick at the base, very viscid while developing, the base permanently invested by the flowering glumes of the host, dark-gray at the base, gradually fading to very light-gray or almost white at the apex; stromata erect, erumpent; stem cylindric or slightly fusiform, short, stout, almost white; head slightly flattened below and overlapping the upper end of the stalk, 2-3 mm. in diameter, light-gray, almost smooth, viscid, covered with small, darker points indicating the position of the perithecia; perithecia immersed, ovoid or subovoid, $190-225 \times 60-90$ mic.; asci narrowly cylindric, slightly narrowed below into a rather long, stout pedicel and slightly enlarged at the point of attachment, $135-150 \times 4-5$ mic.

Growing on the inflorescence of species of *Hilaria*.

TYPE LOCALITY: Cochise, Arizona.

DISTRIBUTION: Known only from the type locality.

ILLUSTRATIONS: Bull. Torrey Club 28: 238, f. 1-2.

ENSICCATI: D. Griff. W. Am. Fungi 97.

4. *SPERMOEDIA NIGRICANS* (Tul.) Seaver, N. Am. Fl. 3: 55. 1910

Claviceps nigricans Tul. Ann. Sci. Nat. III. 20: 51. 1853.

Sclerotia formed in the inflorescence of the host, 3-5 in a single spikelet, subcylindric or curved, often slightly flattened, brownish to purplish-black externally, white within, longitudinally striate; stromata not seen in American specimens.

On species of spike-rush (*Eleocharis*).

TYPE LOCALITY: Europe.

DISTRIBUTION: North Dakota and South Dakota; also in Europe.

ILLUSTRATIONS: Ann. Sci. Nat. III. 20: pl. 4, f. 15-22.

EXSICCATI: D. Griff. W. Am. Fungi 10. Other specimens examined: North Dakota, *Brenckle*.

5. *Spermoedia Stevensii* nom. nov.

? *Sclerotium Paspali* Schw. Schr. Nat. Ges. Leipzig 1: 268. 1822.

? *Spermoedia Paspali* Fries, Syst. Myc. 2: 268. 1822.

Claviceps Paspali Stevens & Hall, Bot. Gaz. 50: 462. 1910.

Sclerotia yellowish to gray, globose, roughened when mature, about 3 mm. in diameter; head dull yellow; stipe short to medium usually not more than 1 cm. long; perithecia completely covering the head, numerous, ovoid, 340×119 mic.; asci cylindric, 174 mic. long; spores filiform, $101 \times 0.5-1$ mic.

On species of *Paspalum*.

TYPE LOCALITY: North Carolina.

DISTRIBUTION: Known only from the type locality.

ILLUSTRATIONS: Bot. Gaz. 50: 460, f. 1, and 461, f. 2, 3, 5.

6. *Spermoedia Rolfssii* (Stevens & Hall)

Claviceps Rolfssii Stevens & Hall, Bot. Gaz. 50: 462. 1910.

Sclerotia yellowish to gray, globose, roughened when mature, about 3 mm. in diameter; head dull yellow; stipe filiform, 1-1.5 cm. long; perithecia few in head and mostly upon extreme distal portion, cylindric-ovate, 816×225 mic.; asci cylindric, 375×3 mic.; spores filiform, $260-275 \times 0.5-1$ mic.

On species of *Paspalum*.

TYPE LOCALITY: North Carolina.

DISTRIBUTION: Known only from the type locality.

ILLUSTRATIONS: Bot. Gaz. 50: 461, f. 3, 4.

7. *Spermoedia Tripsaci* (Stevens & Hall)

Claviceps Tripsaci Stevens & Hall, Bot. Gaz. 50: 463. 1910.

Sclerotia smooth, white to dark brown or black, nearly conical, 4-5 mm. in diameter at the base; heads gray to grayish-white; stipe thick, white to purplish-white, 1-1.5 cm. long; perithecia numerous, ellipsoid in longitudinal section, with a short beak toward the surface of the head, $390 \times 153-187$ mic.; asci cylindrical, $145-175 \times 2-3$ mic.; spores filiform 130 mic. long; conidia hyaline, continuous, fusoid to lunulate, $17.4-37.7 \times 2.9-8.7$ mic.

On gama grass, *Tripsacum dactyloides* L.

TYPE LOCALITY: North Carolina.

DISTRIBUTION: Known only from the type locality.

ILLUSTRATIONS: Bot. Gaz. 50: 462, f. 6.

DOUBTFUL SPECIES

Claviceps ? *caricina* D. Griff. Bull. Torrey Club 29: 300. 1902.

This is said to be *Sclerotium sulcatum* Desm. (See Mycologia 3: 38. 1911.)

38. *BALANSIA* Speg. Anal. Soc. Ci. Argent. 19: 45. 1885.

? *Ephelis* Fries, Summa Veg. Scand. 370. 1849.

? *Ophiodothis* Sacc. Syll. Fung. 2: 652. 1883.

Dothichloe Atk. Bull. Torrey Club 21: 223. 1894.

Sclerotia consisting of a more or less compact fungous tissue formed in the stems or inflorescence of plants; stromata arising from the sclerotium, stipitate and capitate or sessile, separated from the sclerotium by a constriction; perithecia immersed in the stroma; asci 8-spored; spores filiform, nearly as long as the ascus.

Type species: *Balansia claviceps* Speg.

1. *BALANSIA HYPOXYLON* (Peck) Atk. Jour. Myc. 11: 254. 1905

? *Ephelis mexicana* Fries; Berk. Jour. Linn. Soc. 10: 353. 1868.

Epichloe Hypoxylon Peck, Ann. Rep. N. Y. State Mus. 27: 108. 1875.

Hypocrella Hypoxylon Sacc. Syll. Fung. 2: 581. 1883.

? *Ephelis borealis* Ellis & Ev. Jour. Myc. 1: 86. 1885.

Dothichloe Hypoxylon Atk. Bull. Torrey Club 21: 223. 1894.

Sclerotia formed in the fruiting axes of the host, curved and

irregular, 1 cm. or more in length, grayish or blackish; stromata black, prominent, pulvinate or subhemispheric, 1-5 mm. in diameter, several springing from the same sclerotium, minutely roughened by the slightly protruding perithecia; perithecia immersed; asci cylindric, with a pedicel at the base, as much as 20 mic. in length; spores 1 mic. thick, at maturity breaking into segments 3-4 mic. long.

On *Danthonia spicata* (L.) Beauv., and other grasses.

TYPE LOCALITY: Sandlake, New York.

DISTRIBUTION: Maine to South Carolina, Texas and Iowa.

ILLUSTRATIONS: Jour. Myc. 11: pl. 81, 82, 38.

EXSICCATI: Ellis & Everh. N. Am. Fungi 2373. Barth. Fungi. Columb. 3027. Other specimens examined: Connecticut, *Sheldon*; Iowa, *Buchanan*; Nova Scotia, *Dearness*.

DOUBTFUL SPECIES

Balansia discoidea P. Henn. Hedwigia Beibl. 39: 77. 1900.
Doubtfully reported from North America.

DOUBTFUL GENUS

USTILAGINOIDEA Bref. Unters. Gesammt. Myk. 12: 194. 1895.

The imperfect stage of this fungus resembles a smut and the perfect stage is said to be similar to *Spermoedia*; the genus has been placed in the Hypocreales by Lindau. *Ustilaginoidea Oryzae* (Pat.) Bref. loc cit., commonly known as the green smut of rice, is reported as occurring in Louisiana. No specimens have been seen.

NEW YORK BOTANICAL GARDEN.

EXPLANATION OF PLATE 53

Figs. 1-5. *Cordyceps clavulata* Schw. Figs. 1-3 after Berkeley and Curtis.

Fig. 1. Two plants on scale-insect, natural size.

Fig. 2. Scale-insect with a number of sterile plants.

Fig. 3. Scale-insect with mature plants.

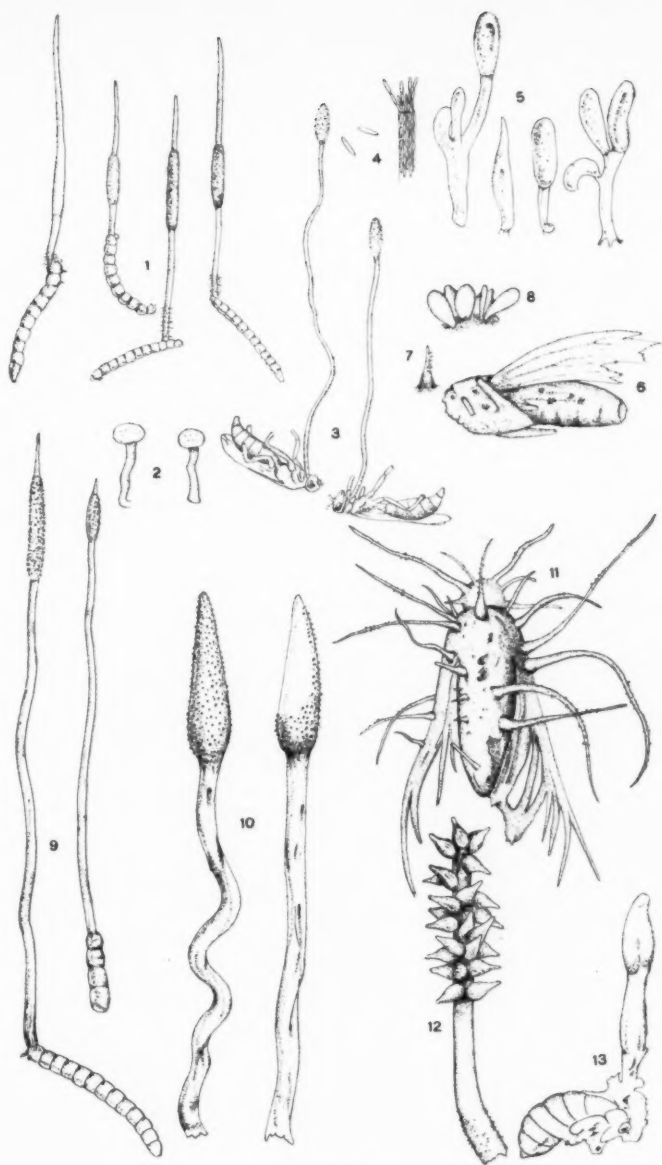
Fig. 4. Ascus with spores.

Fig. 5. One spore removed from ascus.

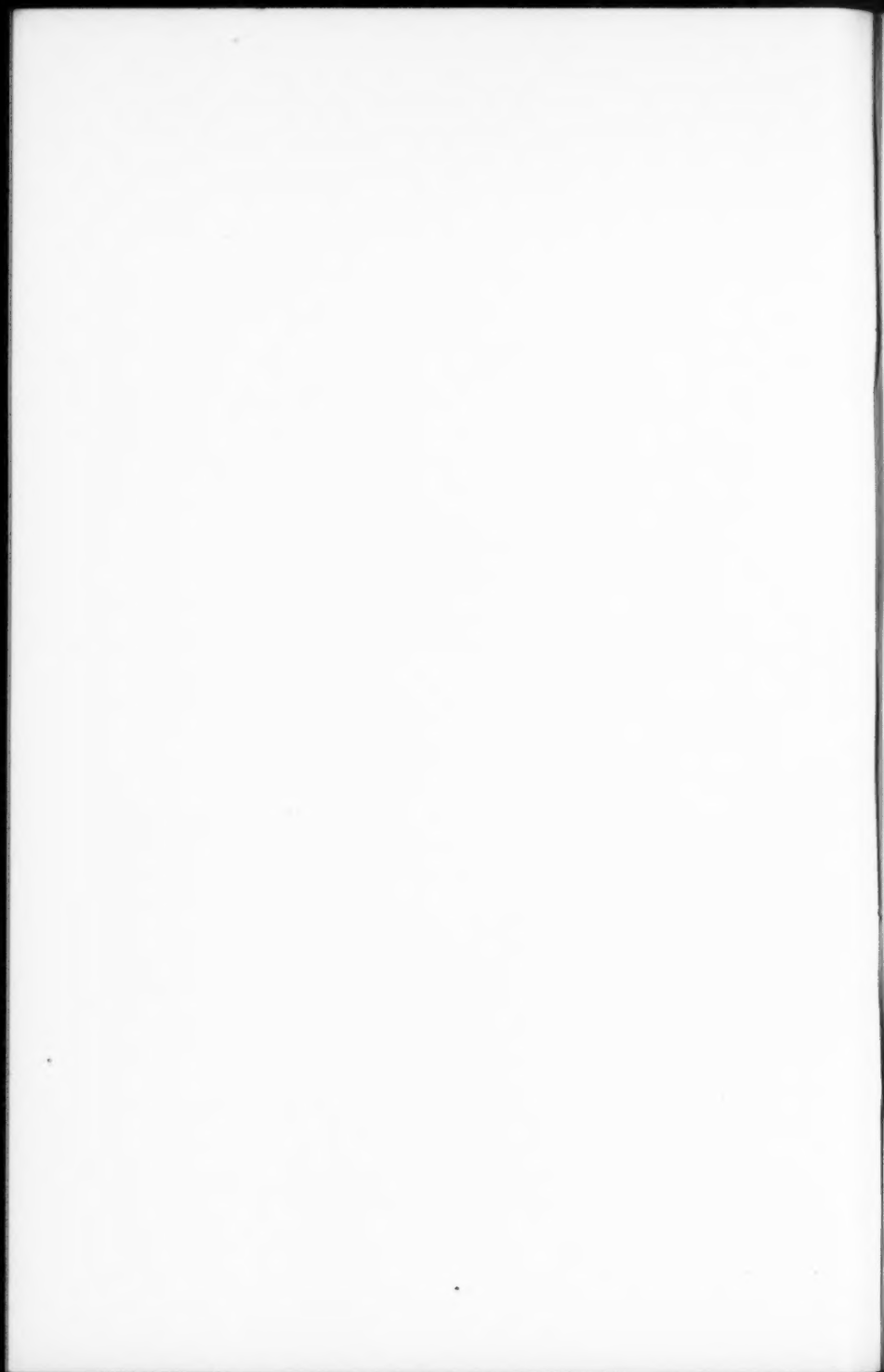
Fig. 6. *Cordyceps herculea* (Schw.) Sacc. Copied from photograph in herbarium of the New York Botanical Garden, about natural size.

Fig. 7. *Cordyceps entomorrhiza* (Dicks.) Link. Copied from the original drawing.

Figs. 8-9. *Cordyceps agariciformia* (Bolton) Seaver.



CORDYCEPS



- Fig. 8. Two plants copied from the original drawing.
 Fig. 9. Portion of ascus and spore segments.
 Figs. 10-11. *Cordyceps militaris* (L.) Link.
 Fig. 10. Two plants on cocoon, about natural size.
 Fig. 11. Ascus and spores.
 Figs. 12-13. *Cordyceps parasitica* (Willd.) Seaver. Copied from original drawing, about natural size.

EXPLANATION OF PLATE 54

- Fig. 1. *Cordyceps stylophora* Berk. & Br. Copied from original drawing.
 Fig. 2. *Cordyceps armeniaca* Berk. & Curt. Copied from original drawing.
 Figs. 3-4. *Cordyceps sphecocephala* (Klotzsch) Massee.
 Fig. 3. Two plants copied from Tulasne.
 Fig. 4. Portion of ascus with spores.
 Fig. 5. *Cordyceps palustris* Berk. & Br. Copied from original drawing.
 Figs. 6-8. *Cordyceps Cockerellii* (Ellis & Everh.) Ellis. Drawn from original material.
 Fig. 6. Remains of insect showing clusters of perithecia.
 Fig. 7. Portion of erect stroma with perithecial clusters.
 Fig. 8. Cluster of perithecia.
 Fig. 9. *Cordyceps acicularis* Rav. Copied from original drawing.
 Fig. 10. *Cordyceps Ravenelii* Berk. & Curt. Copied from original drawing.
 Fig. 11. *Cordyceps Sphingum* (Schw.) Berk. Copied from Tulasne.
 Fig. 12. *Cordyceps isarioides* M. A. Curtis. Copied from Massee.
 Fig. 13. *Cordyceps sobolifera* (Hill.) Sacc. Copied from Tulasne.

INDEX

The following is the index to the species in the Hypocreales of North America—I (Mycologia 1: 41-76. 1909);—II (Mycologia 1: 177-207. 1909);—III (Mycologia 2: 48-92. 1910) and—IV (Mycologia 3: 207-225. 1911).

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- Helleri* II, 182

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THE NATURE AND CLASSIFICATION OF LICHENS.—I. VIEWS AND ARGUMENTS OF BOTANISTS CONCERNING CLASSIFICATION*

BRUCE FINK

Early in November, 1909, circular letters were sent to 75 American botanists and an equal number of foreign botanists asking for their views regarding the classification of lichens. Gathering data of this kind is an unusual method of approaching a scientific problem; but it was thought that the views of botanists might aid in the final solution of the problem. No man is able to express himself very certainly on the classification of all plants; consequently it is not surprising that certain men who write regarding the classification of many or all of the large groups of plants expressed themselves very doubtfully when asked for a statement. As was to be expected a rather small proportion of those who replied made statements which are of great value. The form of the circular letter is given below.

Botanical Laboratory, Miami University, Oxford, Ohio, U. S. A.
Nov. 8, 1909.

The undersigned wishes the following questions answered by a considerable number of leading botanists. The results of the correspondence will be given, partly in tabulated form, in a paper to be prepared as soon as possible after obtaining the necessary data. The replies will be held strictly private, the information being used without the names of those giving it. However, it may seem best to publish with the paper a list of the names of the botanists who have replied, and the writer will consider himself at liberty to use thus the names of those who make no objection to this in replying. The questions are:—

1. Have you arrived at a conclusion regarding the classification of lichens?
2. Should the lichens be maintained as a distinct class of plants, or should they be distributed among the fungi?

* Contributions from the Botanical Laboratory of Miami University.—VI.

3. What are the arguments upon which your answer to the second question is based?

It is desired that all shall *answer at least the first question*, and if this is answered affirmatively, *then at least the second also*. The third question is, of course, of special importance, and the *writer wishes as many answers to it as can be obtained*, based upon present knowledge or such investigation as can be made in short time.

Those addressed are at liberty to include in their answers matter not directly replying to the three questions if they think best. The botanists addressed have been selected with great care from Europe and America, and the answers it is hoped, besides giving the consensus of opinion, may also contribute to a solution of the problem involved.

(Signed) BRUCE FINK.

The letter was couched in general terms suited to those who believe that lichens should be regarded as fungi and also to those who think that these plants form a group entirely distinct from fungi. It was expected that some botanists would understand that the distribution meant was that of the text-books or of Fünftück and Zahlbruckner in Engler and Prantl. Second letters were written to four botanists who took this view. In these letters, it was stated that the distribution intended was one which would do away with the group Lichenes. These four had stood for distribution in their first replies; but all but one of them refused to stand for distribution to the exclusion of Lichenes. Sixty-three (63) American and 45 foreign botanists replied without a second request. The number of Americans was regarded sufficient to furnish the current views and arguments, but second letters were sent to 12 Europeans in order to increase the number of foreign replies. Of these, 7 replied, making the total number of foreign replies 52.

Careful study of the preparation of those botanists who replied showed that they are not greatly influenced by the opinions held by their teachers. Being influenced by views held at large botanical centers would usually be impossible, for where replies were received from two or more men from the same center there was not an instance of accord in all particulars, and the views expressed were more often widely divergent or quite opposed.

However, botanists are influenced in their thought regarding lichens by "tradition," a fact that appears in writing about these plants, though not so certainly in the views expressed as in the faulty and ambiguous phraseology used.

Of 115 replies, 19 or about 17 per cent. favor distribution, and 14 more or about 12 per cent. think that lichens may be distributed, but for one reason or another prefer that they shall remain a distinct group. About 29 per cent. of those who replied admit the possibility of distribution, though only the 17 per cent. favor it outright. Twenty-one (21) American and 11 European replies state that lichens may or should be distributed. Twenty-three (23) American and 30 European replies state that lichens compose a group with distinct characters. Twenty-nine (29) American and 14 European replies state that lichens should be retained in a special group for practical purposes. Nine (9) Americans and 12 Europeans mention dual nature of lichens or consortism as the basis for maintaining the group Lichenes. By a series of proportions ($49:63::11:x$, etc.) the relative opinion of Americans and Europeans may be obtained, based upon what would appear in an equal number of replies from America and Europe. By such proportions, it appears that, had the number of replies been equal from the two countries, 14 Europeans and 21 Americans would have stood for distribution as desirable or at least a feasible solution. For lichens as a group with distinct characters the proportion would be 39 Europeans and 23 Americans, for the group Lichenes for convenience 17 Europeans and 29 Americans, and for expressed belief in the dual nature of lichens 15 Europeans and 9 Americans.

Botanists, it would appear from the correspondence, may be divided into three groups: those who regard classification a practical matter or an applied science; those who think that classification should, first of all, express relationship or be natural; and those who give nearly equal weight to each of these matters. Assuming that the number of replies from each country is sufficient to express the consensus for that country, it would seem from next to the last proportion above that Europeans have more regard for classification as a pure science than do

Americans and are less disposed to make convenience a prominent argument. However, it appears from another proportion that Europeans are more disposed to retain lichens as a distinct natural group than are Americans; and since this is true, there is for them not so much conflict between theoretical and practical considerations, so that one would not expect so much prominence in their replies to the matter of convenience in classification, even though they might be as strongly in favor of it as Americans. The last proportion tends to show that Europeans more commonly favor the dual-nature theory, or, an outright consortium-theory than do Americans. Three (3) Americans and 5 Europeans expressly state that they regard present knowledge insufficient to warrant distribution. On the whole, the proportions and figures seem sufficient to demonstrate that Europeans are less disposed to break with established usage regarding the systematic disposition of lichens than are Americans. This is what might be expected when it is recalled that nearly all the traditions regarding lichens have had their birth in Europe. There is just one notion regarding lichens that has been explicitly expressed in America only and that is that they should be distributed to the exclusion of the class Lichenes. Careful inquiry and thorough examination of the literature has not brought to light a single instance of such distribution by a European, while three or more Americans have distributed lichens in papers or books.

It would be impossible to state many of the views expressed in the correspondence except in the tabular presentations given below.

By inference or direct statement, 15 clearly defined reasons for maintaining lichens as a distinct group of plants are contained in the replies (see first table) while only two reasons are assigned for distributing them (see second table). Those who replied are grouped as well as could be done according to their fields of botanical work. Twenty (20) replies came from botanists who are known for work not falling in fields contained in the same vertical column in the tables. The views of these persons are given in each of two vertical columns, while those of the remaining 95 botanists are expressed only once in the tables. The figures (16-1*) under lichenists in the first vertical column of the

TABLE GIVING THE ARGUMENTS FOR MAINTAINING LICHENS AS A DISTINCT GROUP OF PLANTS

	Lichens	Mycologists and Pathologists	Morphologists and Anatomists	Physiologists and Ecologists	Systematists	Misc.	Totals
1. Because a group with distinct characters	24	39	33	15	16	9	
2. For the sake of convenience in study	16-1 ^a	10-5 ² -1 ^a	9-3 ² -1 ^a -1 ^a -6	4-1 ² -1 ^a -6	4-1 ^a	4-1 ^a	47
3. Because of the dual nature of lichens	4-1 ^a	17-1 ² -2 ^a -1 ^b	13-1 ¹ -1 ^a -2 ^a	7-1 ¹	0	3	44
4. Because present knowledge is not sufficient to distribute	6	2	7	3-1 ^a	3	2	23
5. Because of special methods of sexual reproduction	1	3	4	1	1	0	10
6. Because of special methods of vegetative reproduction	1	0	0	0	0	0	1
7. Because of peculiar physiological relations	0	2	1	0	0	0	1
8. Because they form a peculiar biological group	0	0	0	1 ^a	1 ^a	1	3
9. Because of the peculiar vegetative structure	2	2	0	0	0	1	5
10. Because of the large size of the group	0	1	0	0	0	0	1
11. Because of the chemical reactions of the thalli	1-1 ¹⁻³	0	0	0	0	0	1
12. For arrangement by themselves in herbaria	0	1	0	1	2-1 ^a	1	5
13. Because of the large literature of lichenology	0	1	0	1	0	0	2
14. Because of the distinct group of workers	0	1	0	0	0	0	1
15. Because the thecia are parasitic structures	1	0	0	0	0	0	1
Totals	33	40	34	17	10	12	146

TABLE GIVING THE ARGUMENTS FOR DISTRIBUTING LICHENS AMONG OTHER FUNGI

	Lichens	Mycologists and Pathologists	Morphologists and Anatomists	Physiologists and Ecologists	Systematists	Misc.	Totals
a. Because lichens addressed in each group	24	39	33	15	16	9	
b. Because lichens do not form a natural group of plants	2-2-1 ²	{ 9-1 ² -10-11-6 ¹ }	8-3 ²	4-1 ² -1 ² -11-12	3-1 ¹⁻²	1-1 ²⁻⁶	27
c. Because of the resemblance of the fruit to that of other fungi	0	1	0	1	0	0	2
d. No reason assigned	0	0	0	0	1	0	1
Totals	2	10	8	5	4	1	30

first table mean that 16 lichenists favor maintaining lichens as a natural group while one thinks that the grounds for distribution are stronger though there are reasons for maintaining the group. Figures (10-5²) in the second vertical column of the first horizontal row mean that 10 mycologists and pathologists think that lichens should be maintained as a natural group while five think that they are probably a natural group, but should in any event be kept distinct for the sake of convenience in study. The combination 1^{a-b} in the first horizontal row and the third vertical column means that one morphologist or anatomist thinks that lichens may form a natural group, but that they more probably do not for reasons given under (a) and (b) in the table giving reasons of distributing the lichens. The figures (2-2¹-1²) in the first vertical column of the first horizontal row of the second table mean that two lichenists believe that lichens should be distributed because not a natural group; that two others think there are arguments for this view, but that there is stronger argument for the validity of the natural group *Lichenes*; and that one other lichenist thinks that lichens are perhaps not a natural group but that they should be kept distinct for the sake of convenience in study. With these explanations it is believed that a study of the two tables will make the figures in the columns intelligible. The total for each horizontal row of figures gives the number of times that the view expressed in that row is favored in the replies; and the totals for each vertical column of figures indicates the number of times that all the arguments for maintenance or for distribution are favored by all the botanists belonging to the group placed in this vertical column. By way of illustration the opinion that lichens form a natural group is expressed 47 times, and reasons for maintaining these plants as a distinct group are expressed 33 times by lichenists. The vertical and the horizontal grand totals agree of course. The whole number of expressions favoring maintenance (146) is much larger than the number of botanists who stated that they favor distribution, because some of the replies give more than one reason for maintaining the group and because the views of 20 botanists are expressed in two columns for the reason stated above. The figures with exponents are not expressed in the totals and, since the first choices are ex-

pressed in figures without exponents, may be omitted in consideration of the tables by those who do not care to go into this rather difficult detail.

The total number addressed in each group of botanists indicates the policy employed in selecting botanists to whom to write. The opinions of lichenists were especially sought, even to the extent of addressing two or three amateurs in this field. So the number of lichenists addressed is somewhat above the average number in the other groups, though lichenists are few in number. After lichenists, mycologists were especially sought; and a large number of pathologists was secured because mycologists are so often also pathologists. In any consideration of classification, the views of a considerable proportion of the great number of morphologists and anatomists must be taken into account. Physiologists were addressed with a view to ascertaining what they might say about the relation of the peculiar biological condition in lichens to classification. Finally, a sufficient number of systematists, other than lichenists and mycologists, was consulted to ascertain how wide a view these persons might have regarding problems of classification in general and the classification of lichens in particular. Those who expressed no opinions or none that could be interpreted and recorded are two amateur lichenists, one mycologist, one morphologist, one anatomist, one physiologist and three systematists. Corresponding vertical columns in the two tables show that the expressions by lichenists are nearly unanimously in favor of maintaining the group *Lichenes*, while about one-fourth of those by other botanists are favorable to abandoning the group.

The first two rows of horizontal figures in the first table show that while the lichenists stand very largely for the integrity of the group, other botanists are much more largely in favor of maintenance for purposes of convenience than because they consider the group a natural one.

Further examination of the first table shows that besides the arguments for maintenance expressed in the first three horizontal rows of figures and already considered, the only other one noted by a considerable number of botanists is that expressed in the fourth horizontal row. Nine Europeans expressed this view (that present knowledge is not sufficient to distribute) and only

one American. It would not be in order in this paper to consider whether the views expressed after the first four horizontal rows of figures are of relatively little importance; but it may be stated here appropriately that the views expressed in the first horizontal lines in each of the two tables are, neither of them, of considerable value unless accompanied by argument or at least a brief statement of reasons why lichens do or do not form a distinct group of plants.

Although the circular letter stated that the views of botanists would not be given over their signatures, a number of correspondents replied that they did not object to being quoted. Very probably permission of all might have been obtained to use their names with the quotations. No amount of tabulation and presentation of data could take the place of extensive quotation, but the arguments presented in the quotations may be more valuable given impersonally. The quotations were selected to express best the various arguments advanced. Twenty-one (21) of the quotations are from foreign botanists and an equal number from Americans, the character of the foreign replies being such that the number chosen for quotation is large in proportion to the number of foreign replies received. All of the foreign replies quoted save one are from European botanists. The preliminary statements of the replies are seldom quoted, and in some instances only a small portion of the reply is used. It has seemed best to give each quotation in a single paragraph and to preserve uniformity in use of italics in this paper though this often changes the form used by the one quoted. The quotations are given in the order of presentation of data in the two tables. After each quotation will be found the main division or divisions of botanical work in which its author is engaged, and the number or letter or numbers or letters under which the quotation is classified in the tables. When two possible solutions are advanced with a preference for one of them, the letter or figure representing what the one quoted regards the less satisfactory solution is followed by a minus sign. The portion followed by the minus sign is reduced, in parentheses, to the form used in the tables. So large a number of quotations is necessary, since each one expresses some important view not contained in the others, or makes some point very

apparent by brevity or clearness. It has seemed best to give the quotations without comment, leaving botanists to draw their own conclusions, except for the statistics and the summary and conclusions, which it is hoped are given without color. *The writer reserves the expression of his views, his estimate of the correspondence, and the consideration of the literature of the subject to following papers of this series.* The quotations are numbered in order that they may be referred to readily in the papers to follow in the series.

Quotation 1

To place the Lichens with the Fungi to which the parasites belong, is, in my opinion, the only scientific and logical mode of treatment. If classed separately, then a precedent is established in favor of treating all symbiotic organisms in a similar manner. Educationally, such a method is bad and certain to create confusion in the minds of students. This may be overcome in a measure by very careful treatment on the part of the teacher, but even so, there will always remain an element of doubt. This position is taken by Strasburger in his latest edition, and voices what I should conceive to be the general opinion. I do not go with him, however, in relegating such organisms to a distinct class, because the ground of expediency which he urges is not at all adequate. It is such an arrangement that constitutes, in my opinion, a very unscientific arrangement. I think it would be far better if they were placed between the Ascomycetes and the Basidiomycetes in such a manner as to exhibit their real genetic relations. This might be done by making Class-Ascomycetes, Class-Ascolichenes, Class-Basidiolichenes, Class-Basidiomycetes. The alga does not count in any such classification, as it is wholly subordinate to the parasite. *Morphologist*, 1, or possibly a.

Quotation 2

My position with reference to questions 2 and 3, as to whether lichens should be maintained as a distinct class and why, is that of Reinke, who as you are well aware maintains that they are physiologically, as well as morphologically sufficiently distinct

from both fungi and algae to be recognized as a distinct class. The fact that when either of the symbionts is removed the autonomy of the lichen ceases to exist is also a strong argument for the maintenance of a lichen class. *Ecologist, Mycologist, 1.*

Quotation 3

I think that it is expedient to preserve the lichens as a class. It seems to me, indeed, that the lichens constitute a special line of evolution; without doubt the algae and the fungi associated have each preserved the structure and the development which are characteristic of them; but the association has acquired some new characters which are all dependent upon the ordinary factors of evolution as the numerous forms and varieties that exist give evidence. The distribution of the lichens among the other fungi would result, in my opinion, in failure to recognize this essential point of the biology of these organisms. *Morphologist, 1.**

Quotation 4

With reference to your question on lichens, I consider that they should be maintained as a distinct class. I hold this view on the grounds that the fungi of the lichen have become specially modified in relation to their symbiotic mode of life. This is seen by one fact that only one or two of the lichen fungi are known in the free state. We are therefore ignorant of them in the free state, and so they cannot be studied as fungi. *Mycologist, 1.*

Quotation 5

The lichens must be treated as a special class, since the connecting links with the fungi are very few, and nearly all living species

* Je pense qu'il est utile de conserver la classe de Lichens: il me semble en effet que les Lichens constituent une ligne d'évolution spéciale: sans doute l'algue et le champignon associés ont conservé chacun la structure et le développement qui leur sont propres: mais l'association a acquis de nouveaux caractères qui sont tous la dépendance des facteurs ordinaires de l'évolution comme en témoignent les nombreuses formes et variétés qui existent. Distribuer les Lichens parmi les autres champignons aurait pour résultat, à mon avis, de méconnaître ce point essentiel de la biologie de ces êtres.

have surely arisen from lichens and have thereby separated themselves widely from the fungi. *Lichenist*, 1.*

Quotation 6

Lichens are unquestionably cryptogams. They cannot be classed as algae because they are not algae. They cannot be classed as fungi, because they are not fungi. A lichen is the mutualistic association of an alga and a fungus. This mutualism has evolved to such a degree that a distinct autonomy is established. Any attempt to separate the two mutualistically associated components destroys the autonomy. It is true that lichens on the one hand merge into the algae and on the other hand into the fungi. Nevertheless there is no such thing as a lichen unless we have an association of an alga and a fungus, an association which is to be compared to the association of living plastids in the cell. The relationship of fungus and alga in the lichen is not parasitic for both symbionts are benefited. The biological relationship has progressed so far that neither symbiont can exist alone, excepting perhaps in the very lowest types. Such a relationship of two or more originally wholly distinct organisms is designated as individualism and constitutes a distinct autonomy. There is no more excuse for classing lichens as fungi than there is for classing fungi as algae. Fungi are supposed to be a degenerate off-shoot from the class algae, are therefore nothing but modified algae and should, to follow the lead of the fungus-lichenologists, be classed as algae. Mosses are evolved from liverworts, and yet we do not class them as liverworts. Lichens are evolved from fungi and algae and have acquired such distinctive characters that we cannot class them with either fungi or algae. *Lichenist*, 1, 3.

Quotation 7

I think that the lichens cannot constitute a distinct class of cryptogams, but that in consideration of the character of the

* Die Flechten müssen als eine besondere Klasse behandelt werden, da die Anknüpfungspunkte zu den Pilzen verschwindend wenige sind und fast alle jetzt lebenden Arten sicherlich aus Flechten entstanden sind und sich dabei weit von den Pilzen entfernt haben.

organs of fluctification, the lichens are to be subordinate to the fungi. The lichens are different from the latter especially by reason of their biological characters. The less evolved fungi are perhaps saprophytes, from which are derived those which are sapro-parasites and finally those which are obligative parasites. The lichens may (?) be regarded as fungi which have realized through mutualistic symbiosis a more perfect biological condition as compared with the obligative parasitic fungi in which is illustrated only an antagonistic symbiosis. *Mycologist, Miscellaneous, 1, 3.**

Quotation 8

The lichens being, as is perfectly demonstrated, the result of a symbiosis between an alga and a fungus, must be classified as a special group, related to the Ascomycetes on one side and to the Basidiomycetes on the other. *Mycologist, 1, 3.†*

Quotation 9

Immediately after the appearance of the treatise upon the lichens, by Professor Schwendener, I accepted his opinion, that the algae and the fungi, which constitute the lichens, are quite independent beings and belong to two different classes of organisms. But, according to my opinion, the lichens are not a case of parasitism as Professor Schwendener affirms; I look upon them as the first example, known to science, of the evolution of a higher organism on account of the union (the symbiosis) of two more simple organisms. I even suppose (but this still remains to be

* Je pense que les lichenes ne peuvent pas constituer une classe distincte de cryptogames, mais que en considerations des caractères de l'appareil de la fructification les lichenes sont à subordonner aux champignons. De ces derniers les lichenes sont differents praecipue pour des caractères biologiques. Les champignons moins évolués sont (peut-être?) des saprophytes, desquels sont dérivés ceux qui sont saproparasites et ensuite les parasites obliges. Les lichenes peuvent (?) être regardés comme des champignons qui ont réalisés avec la symbiose mutualistique une condition biologique plus parfaite en comparaison des champignons parasites obliges où s'explique seulement une symbiose antagonistique.

† Les Lichens étant, comme il est parfaitement démontré, le résultat d'une symbiose entre une algue et un champignon, doivent être classifiés dans un "groupe spécial" annexé aux Ascomycetes d'une côté et aux Basidiomycetes de l'autre côté.

proved with certainty) that all living organisms, both plants and animals, are nothing else than colonies of more simple organisms, living in symbiosis. For this reason the lichens must be again united in a separate class, equivalent to the classes, algae and fungi. *Physiologist*, 1, 3.*

Quotation 10

It appears scarcely desirable to join the lichens with the fungi. The constant occurrence of symbiosis, which these plants present, to which also they owe their very origin, and the special characters realized in their morphology, which permit, in the greater number of cases, of distinguishing at first sight a lichen from an alga or a fungus appear to me to argue in favor of their maintenance as a class. Otherwise the same lichen should be placed at once among the algae and among the fungi: and if such a solution rests upon philosophic foundations, it appears to me of practically little advantage, since it would be far, it seems to me, from simplifying the classification. *Bryologist*, 1, 9.†

Quotation 11

Since the thallus of lichens represents a symbiosis of Ascomycetes with Algae (Cyanophyceae or Chlorophyceae), it is perhaps

* Tout de suite, après l'apparition du traité sur les Lichens de M. le professeur Schwendener, j'ai accepté son opinion, que les algues et les champignons, qui constituent les Lichens, sont des êtres tout à fait indépendants et appartiennent à deux différentes classes d'organismes. Mais, selon mon opinion, les Lichens ne sont pas des cas de parasitisme, comme l'affirme M. le professeur Schwendener; je les envisage, comme le premier exemple, acquis par la science, de l'évolution d'un organisme supérieur, par la réunion (la symbiose) de deux organismes plus simples. Je suppose même, ce qui est certainement à prouver, que tout les êtres vivants: plantes et animaux ne sont que des colonies des organismes plus simples, vivant en symbiose. Par cette raison les Lichens doivent être de nouveau réunis dans une classe apart, équivalente aux classes des algues et des champignons.

† Il me paraît peu désirable de voir réunir les Lichens aux Champignons. Les faits constants de symbiose qu'ils présentent et aux quels ils doivent leur origine même, et les caractères spéciaux réalisés par leur morphologie, et qui permettent, dans la plupart des cas, de reconnaître à première vue un Lichen d'une Algue ou d'un Champignon, me semblent plaider en faveur de leur maintien comme classe. Autrement le même Lichen devrait être placé à la fois parmi les Algues et parmi les Champignons; et si une telle solution repose sur des bases philosophiques, elle me paraît pratiquement peu avantageuse, car elle serait loin, me semble-t-il, de simplifier la classification.

logically necessary to arrange them under the fungi, or under the algae. It need only be borne in mind that the study of this interesting class of plants will be rendered difficult for many because we have hitherto considered them as a separate family. *Systematist*, 1?, 3, a?.*

Quotation 12

It is not possible at present to intercalate the lichens in the fungus system in a logical, satisfactory manner, nor is it opportune. In order to distribute the lichens among the fungi in the proper places, we must know thoroughly those fungi from which the individual lichen-series arose. Though the lichenists have occupied themselves with this question for a long time, we do not yet know the fungi which first entered into the consortium. Nor is there much hope of knowing these fungi, since the fossil lichens, which could serve as guides, are wanting and the recognition of the original consortium fungi has been rendered difficult through the fact that the primitive fungus has undergone transformation in the consortium and probably, as a lichen-former, entered upon a different phylogenetic path than that taken by the primitive fungus which did not enter into the consortium. In this I fix my eyes upon the present condition of lichenology, for we cannot pass judgment on what science may yet discover. Now, one can distribute the lichens in the fungus system according to the apothecium-type, but nothing new is gained thereby, indeed the parallelism in this respect is sufficiently well known. Or one may insert the lichen-groups in the fungus-system approximately according to their points of departure: The Coniocarpei perhaps after *Stilbum*, the Graphidaceae (including *Rocella*) after *Hysterium*, the *Lecidea-Usnea* series after *Patellaria* and here also the Cyanophile for most part, etc. Thereby would come about a quite bizarre fungus-system. It would certainly seem odd to find the *Opegrapha-Rocella* series after *Hysterium* and the related fungus-genera, or the *Lecidea-Usnea* series after *Pragmopara*, etc. But

* Da der Thallus von Lichenes eine Symbiose von Ascomyceten mit Algae (Cyanophyceen oder Chlorophyceen) darstellt, so ist es wissenschaftlich wohl nötig, sie unter die Fungi, resp. Algae einzureihen. Zu bedenken ist nur, dass für viele das Studium dieser interessanten Pflanzenklasse erschwert wird, da man sie bisher als eine geschlossene Familie betrachtete.

would we thus arrive at a scientific conclusion, could such a system also be pronounced a natural one? Certainly not. It is best, considered entirely from a practical point of view, to keep the lichens together and not parcel them out on an insufficient scientific basis, thus tearing the whole lichen-kingdom into shreds. Also the consideration that the thallus development has taken a way entirely different from that of the Fungi, and the peculiar ability of the lichen thallus, not present in the fungi, to manufacture lichenic-acids may be drawn near as supports for my view. It is also self-evident that, in an independent treatment of the lichen-kingdom, the modern lichenist will not for a moment forget that the lichens are descendants of the fungi and will be especially conscious of this when he pursues phylogenetic lichen investigations. *Lichenist*, 1^o, 2, 4, 11.*

* Es ist heute nicht möglich in wissenschaftlich befriedigender Weise die Flechten in das Pilzsystem einzuschalten, auch ist dies nicht opportun. Um die Flechten im Pilzsystem an den richtigen Stellen unterzubringen, müssten wir genau jene Pilze kennen, von welchen die einzelnen Flechtenreihen ihren Ausgang nahmen. Trotzdem sich die Lichenologen schon seit längerem mit dieser Frage befassen, kennen wir derzeit jene Pilze, welche zuerst in das Konsortium eintreten, nicht. Es ist auch wenig Hoffnung vorhanden, diese Pilze kennen zu lernen, da uns fossile Lichenen, welche als Wegweiser dienen könnten fehlen, und die Erkenntnis der primären Konsortiumspilze dadurch erschwert wird, dass auch der ursprüngliche Pilz im Konsortium Veränderung erlitt und entwicklungsgeschichtlich als Flechtenbildner wahrscheinlich andere Wege einschlug, als der nicht in das Konsortium getretene primäre Pilz. Hierbei fasse ich nur den dermaligen Stand der Lichenologie ins Auge, denn darüber, was die Wissenschaft noch bringen wird, steht uns kein Urteil zu. Nun könnte man ja, entsprechend dem Apotheziumtypus die Flechten in Pilzsystem einreihen, doch damit ist nichts Neues gewonnen, ja der Parallelismus in dieser Beziehung ist hinlänglich bekannt. Oder man könnte die Flechtenreihen approximativ nach den Ausgangspunkten derselben ins Pilzsystem einschalten; die Coniocarpei etwa nach *Stilbum*, die Graphidaceae (bis inclusive *Rocella*!) hinter *Hysterium*, den Stamm *Lecidea-Usnea* hinter einer *Patellaria* und hier zugleich auch die Cyanophili zum grössten Teil u. s. w. Dadurch käme ein recht bizzares Pilzsystem zustande; es würde gewiss verblüffend wirken, hinter *Hysterium* und die anschliessende Pilzgattung die Reihe *Opegrapha-Rocella* anzutreffen, oder hinter *Pragmopora* die Reihe *Lecidea-Usnea* u. s. w. Wären wir aber dadurch zu einer wissenschaftlichen Erkenntnis gelangt, würde ein derartiges System auch als natürlich angesprochen werden können? Gewiss nicht. Es ist am besten—von praktischen Gründen gänzlich abgesehen—die Flechten beisammen zu lassen und sie nicht auf wissenschaftlich unzureichender Grundlage zu gestückeln, das ganze Flechtenreich in Fetzen zu reissen. Auch die Erwägung, dass die Thallusentwicklung einen von den Pilzen ganz unabhängigen Weg eingeschlagen hat, die eigenartige, bei den

Quotation 13

I believe that the lichens should be maintained as a distinct class under the fungi, and co-ordinate with the Ascomycetes. The argument for distributing the lichens among the other fungi is based on the close similarity between the lower forms of lichens and certain fungi, it being pointed out that in these forms, algae are present in small numbers or only loosely associated with the fungi. It seems to me, however, that in considering the nature of lichens it is fair to take the typical members of the group, these low forms referred to showing the origin of the group, but not showing its characteristic features. We do not call the Green or Brown Algae "animals" just because the lower members of these groups are scarcely separable from *Flagellata*. Comparing, then, the more typical Lichen-fungi with the true Fungi, there are striking and important differences. (A) The true fungi have been developed from the Algae by adapting themselves to new modes of nutrition and to subaerial habitats. Throughout the group, however, the vegetative body remains simple, the chief differentiation being in the direction of massive fruiting-bodies for the better protection and dissemination of the spores. The evolution of the Lichen-fungi has been in the direction of a massive vegetative body, often highly specialized, and with peculiar methods of vegetative multiplication (soredia). The lichen-thallus is a development of the vegetative body wholly without parallel among the true fungi. There are certain Ascomycetes which are parasitic on Laminarias, but these have the usual simple, filamentous mycelium. It is in the development of the thallus that the parasitism of the lichen-fungi differs. Ephebe, which is exceptional among the lichens, most closely approaches the true parasitic fungi. (B) It may be objected that to base a class on differences in vegetative structure is contrary to the usual principles of classification. But the chief distinctions between the Class:

Pilzen nicht wiederkehrende, Eigenschaft des Flechtenlagers, Flechtensäuren zu bilden, kann als Stütze meiner Auffassung herangezogen werden. Es ist selbstredend, dass auch bei einer selbständigen Behandlung des Flechtenreichs der moderne Lichenologe keinen Moment darauf vergessen wird, dass die Lichenen Descendenten der Pilze sind und wird sich dessen insbesondere dann bewusst sein, wenn er phylogenetische Flechtensudien betreibt.

Hepaticae and the Class: Musci, lie in the vegetative structure, the methods of reproduction being essentially the same in the two groups. (C) Furthermore, it is probable (from the researches of Baur and others) that the processes preceding the formation of apothecia in the lichens, while similar in some respects to the conditions shown by De Bary, and more recently by Blackman and his students, in the Ascomycetes, also differ in important details, notably in the great development of the trichogyne, and the suggested functioning of the spermatia as male cells. This subject, however, of the nature of the contents of the spermatogonia (or pycnidia) is too obscure to furnish the basis for argument on either side. (D) According to the views here advanced the so-called "Basidiolichens" should not be considered as true lichens, since in these forms the algal cells are associated with the fruiting-body, and not with the mycelium to form a thallus as in the typical lichens. To sum up: The lichens are undoubtedly fungi associated, probably parasitically, with algae. While being classified under the Series: Fungi, they should be placed in a class by themselves, on account of the entire group being characterized by a specialized vegetative body, the thallus. *Lichenist*, 1, 5?, 6, 9.

Quotation 14

It is almost universally conceded that the spermogones, pycnides, etc., of the lichen thallus are parasitic fungi. If this be true, there is every reason to believe that the so-called fructification (Apothecia) of lichens are likewise parasitical bodies. Between the thecia of lichens and those of fungi there is said to be an analogy or similarity. And so far as I know this is the only ground for assumed relationship. The similarity ends there. What then may we call the remainder of the highly differenced thing dubbed as Lichen, when externally and internally it is different from any known vegetable growth? I have long believed that the thalli of the higher lichens are invariably reproduced vegetatively, never from the spores of the so-called fruit. With regard to the latter, I have at the same time held the opinion that if these spores reproduced anything at all, it in all probability would be merely other thecial bodies with a likeness to the parent. A

curious circumstance of year before last may be cited here. *Parmelia rudecta* is often found fertile here, *P. saxatilis* less commonly, and *P. crinita pilosella* almost never. On one tree trunk I found the first named uppermost, the second in its form *furfuracea*. Just below, and at the base of the tree, the last, all fertile. Now it will take more than mere argument to convince me that the apothecia or rather thecia of *P. crinita pilosella* were not adventitious with one or the other of the superior plants responsible. The so-called thecia of *Coenogonium* belong to *Gyallecta*, and I know that the thecia of *Theloschistes parietius* and *Placodium elegans* are conspecific. The hyphema of the lichen thallus may resemble those of the mycelium of fungi, may be fungoid, but the thallus is too much modified structurally and morphologically for the parallel to be more than mere resemblance. In the lower lichen together with a conspecific thecial character, there may be a conspecific thalline one. I have found *Lecanora subfusca glabra*, *Conotrema urceolatum* and *Pertusaria velata* growing on the same thallus, and right here is where some investigator can add lustre to his crown of glory. Let him investigate the thalli of the lower lichens and he will find ample proof of the parasitism of the lichen thecia. *Lichenist*, 1, 15.

Quotation 15

I send you the reply to the question that you have asked concerning the lichens. For me the affirmative answer has not the shadow of a doubt, and it is absolutely impossible that those who have worked up the anatomy of certain of the cryptogams should not be of my opinion. Most of those who desire to unite the lichens with the fungi base their view upon the similarity of fructification in certain species of the two classes; but the botanists have only considered one side of the question and this not the principal one. Indeed, a plant must exist before producing fruit and not all necessarily fructify at all. It is, therefore, the means of existence of the lichens, that is to say its thallus, that must be examined first of all. It is in the thallus, moreover, that the consortium, composed of the two elements is found. Therefore, the structure of the thallus, and especially that of its cortex, is entirely different from that of the fungi. The lichens

form a class absolutely distinct from other cryptogams. They result from the association of a fungus and an alga and in consequence they are complex organisms, which by reason of the two elements which compose them, stand entirely distinct. This is so true that if one attempt, in any species of lichen whatever, to identify either the hyphae or the gonidia with the species which appear to be related, either among the fungi or among the algae, one will not usually succeed; a most doubtful placing does not extend beyond the genus, moreover, if one examines the manner in which this consortium operates, one notices that the same hyphae always live together with the same gonidia: no exception to this rule has ever been noted. Therefore the lichen exists on the condition that the spore in sending out its filaments, encounters the alga which was in existence in the thallus which has produced it. This organization of the lichen proves superabundantly that it cannot belong either to the domain of the Fungi, nor to that of the Algae. Finally, the anatomy of the lichens separate them entirely from the Fungi. *Lichenist*, 1, 3, 9.*

* Je vous envoie la réponse à la question que vous avez bien voulu me poser au sujet des lichens. Pour moi la réponse affirmative ne fait pas l'ombre d'un doute et il est absolument impossible que ceux qui ont fait l'anatomie de quelques unes de ces cryptogames ne soient pas de mon avis. La plupart de ceux qui veulent les rattacher aux champignons s'appuient sur l'analogie de la fructification chez certaines espèces des deux classes; mais les botanistes n'envisagent qu'un côté de la question et celui qui n'est pas le principal. En effet une plante doit exister avant de fructifier et toutes ne fructifient pas nécessairement. Ce sont donc les moyens d'existence du Lichen, c'est-à-dire son thalle, qu'il faut examiner avant tout. C'est dans celui-ci du reste que se rencontrent le consortium des deux éléments constitutifs. Eh bien: la structure de ce thalle et particulièrement de son cortex est tout à fait différente de celle des champignons. Les lichens forment une classe absolument distincte des autres Cryptogames. Ils proviennent de l'association d'un Champignon et d'une Algue et par conséquent ils sont des êtres complexes, les quels en raison des deux éléments qui les composent demeurent entièrement distincts. Cela est si vrai que si l'on tente dans une espèce quelconque de Lichen, d'identifier, soit les hyphes, soit les gonidies avec les espèces qui paraissent leurs voisines soit parmi les Champignons, soit parmi les Algues, on n'y parviendra généralement pas; l'appréciation le plus souvent ne dépassera pas le genre. De plus si on examine la façon dont s'opère ce consortium, on remarque que toujours les mêmes hyphes vivent avec les mêmes gonidies: aucune exception à cette règle n'a jamais été signalée. Donc le Lichen n'existe qu'à la condition que la spore en émettant ses filaments, rencontre l'Algue qui existait dans le thalle qui l'a produite. Cette organisation du Lichen prouve surabondamment qu'il ne peut appartenir ni à la classe des Champignons, ni à celle des Algues. Enfin l'anatomie des Lichens les sépare complètement des Champignons.

Quotation 16

From a point of historical continuity I presume they might better be kept as a distinct class. I am not, however, familiar enough with the intimate histology and the life histories of the group to say whether or not from the morphological standpoint they ought to be kept distinct or distributed among the fungi. If they are to be broken up and distributed among the fungi, the distribution should only be made after positive evidence has been obtained in regard to the exact relationships between each lichen genus or family and the fungus genus or family under which it is placed. If a new distribution amongst the fungi is made it should at least tend toward a permanent natural classification and should not be a new classification of convenience. *Mycologist, Pathologist, 1, 4.*

Quotation 17

According to my judgment, it is practical and convenient to maintain the lichens as a distinct class; meanwhile it must be a task of lichen investigation to discover the relation of the individual lichen fungi to the isolated living fungi and to assign the place of each of the former among the latter. *Morphologist, Mycologist, 2, 4.**

Quotation 18

It seems to me that from every point of view the lichens should be kept as a distinct group of plants. To distribute them among the fungi would cause endless confusion. The group is so large and the forms so highly differentiated that merely as a matter of practice they must always have their own following of botanists, who, if they devote themselves to the lichens, can have little time for other specialization. Systems of classification must first and foremost have a basis of common sense, since they are at bottom devices for convenience, and no theoretical arrange-

* Meiner Meinung nach ist es practisch und bequem, die Flechten als besondere Klasse beizubehalten; indessen müsste es eine Aufgabe der Flechtenforschung sein, die Beziehung der einzelnen Flechtenpilze zu den isoliert lebenden Pilzen zu erforschen und jedem der erstgenannten seinen Platz unter den letztgenannten anzuweisen.

ment will ever establish itself in which complexity is offered in place of simplicity. I can illustrate this point with what seems to me an essentially parallel case to the one in point. Certain of the bacteria are so close to the blue green algae as to be very near relatives, perhaps even species of the same genus, but as a matter of practice the science of bacteriology is not likely to confuse its system of classification of the organisms with which it deals by combining the Schizomycetes with the Cyanophyceae. *Morphologist, Cryptogamist*, 1-, 2 (1²).

Quotation 19

If we compare lichens with parasites growing on other plants, such, for instance, as the mistletoe on the apple-tree, or *Peronospora* on some herbaceous plant, it then, of course, is absurd to think of naming the ensemble of host and parasite as one thing, but here there is a question only of simple parasitism. I do not see why we might not with more justice liken the symbiotic forms called lichens to the mixed rocks, where as in granite we have, for instance, varying proportions of quartz, mica and feldspar, and although we know perfectly well that the compound which we call granite is composed of these elements, and we can see these elements in it, we still speak of the mass as granite, and so of puddingstone and other rocks. I do not see that any harm would result from continuing the old method of designating lichens under the lichen name with such modifications as would express the new knowledge. Why would it not be possible to write after the binominal Latin name of the Lichen the Latin name of the fungus involved, followed by the Latin name of the alga, the two being separated by a plus sign and the whole enclosed by a parenthesis. (..... +). This would show at a glance what the ordinary student wants, namely, some name for that particular looking compound which he finds on rocks, trees, etc., and at the same time would furnish the scientific man all the data known respecting the two organisms forming the union. In case the fungus is known but the alga uncertain, or the alga known and the fungus uncertain, it would be very easy to introduce general statements within the parenthesis, *e. g.*,

fungus ? plus so and so. In other cases where neither of the symbionts is known definitely that sort of a statement could go into the parenthesis. *Mycologist, Pathologist, 1* ?, 3.

Quotation 20

If I were classifying lichens for systematic purposes, I should keep them all together as a class as a matter of convenience. If I were making a scientific classification in which I was endeavoring to show actual sequences and relationships, I should distribute them in their natural places near their related fungus forms. Since, however, the lichens have always been studied by themselves and are likely to be for a long time, I see no advantage in trying to make things "natural" in any classification, by making them inconvenient. *Mycologist, 2, a- (1²)*.

Quotation 21

I believe it proper, whether from a scientific or a practical point of view, to keep the fungi and the lichens separate in two classes, the one beside the other. For me the character of the symbiosis with the algae and the peculiar character of the thallus is sufficient to separate the two classes. *Mycologist, 1, 2, 9.**

Quotation 22

From a purely theoretical point of view, a distribution of the lichens among the various fungus orders with which they are related is really a matter of course, there being satisfactory examples to show that lower lichens are in a certain intermediate condition so that one may in various ways fix the bridges between undoubted fungus genera and the lichens related to them. Nevertheless, it seems to me more expedient for the present to keep the lichens as distinct as possible, even for systematic consideration, since their dependence upon the symbiotic algae—especially in the groups that have complicated thallus structure—continually forces

* Je crois convenable, soit au point de vue scientifique que pratique de tenir séparés en deux classes distinctes les fungi et les Lichenes, en les placant tout à fait à côté les uns des autres. Pour moi le caractère de la symbiose avec les algues et d'un thalle tout à fait particulier est suffisant pour séparer les deux classes.

the systematist to a consideration of their physiological isolation. One must of course continually keep in mind that in spite of their well-known polyphyletic origin, the connection of the lower lichens with the fungi is to be further studied as far as possible and that in the study of the respective fungus groups, the consideration of their connection with the related lichens must never be lost from sight. But the relationships are, also, already sufficiently well expressed in just this way. Then, for the rest, the isolation recommends itself because a certain division of labor exists at present, such that a special mycological and lichenological knowledge is seldom found in the same person. Therefore both departments may well, as heretofore, remain distinct and side by side, Lichenology of course always in close relationship with the results of mycological research. . . . Finally, clearness is more important for the systematist than a too puristic system, especially where, as here, he works in a special field. Moreover, in many instances, the conception of phylogenetic relations still vacillates strongly. *Lichenist*, 2, a- (r^2).*

* Vom rein theoretischen Standpunkte aus, ist eine Aufteilung der Flechten in die verschiedenen Pilzordnungen, mit denen sie verwandt sind, eigentlich selbstverständlich, giebt es doch genügend Beispiele dafür, dass niedere Flechten auf einem gewissen intermediären Stadium verharren, sodass man verschiedentlich die Brücken zwischen gewissen Pilzgattungen und den ihnen verwandten Flechten festzustellen vermag. Dennoch will es mir practischer erscheinen, auch gegenwärtig noch die Flechten, selbst bei systematischer Behandlung, möglichst gesondert zu halten, denn ihre Abhängigkeit von den symbiotischen Algen—zumal bei den Gruppen mit komplizierterem Thallusaufbau—zwingt auch den Systematiker forwährend zur Berücksichtigung dieser ihrer physiologischen Sonderung. Man muss sich dabei natürlich stets ihres sicher nachgewiesenen polyphyletischen Ursprunges bewusst bleiben, ja, es ist selbstverständlich der Zusammenhang der niederen Flechten mit dem Pilzen weiter möglichst eingehend zu prüfen und es dürfen bei den betreffenden Pilzgruppen die Hinweise auf die sich an sie anschliessenden Flechten niemals fehlen. Damit ist aber auch die Zusammengehörigkeit bereits genügend ausgedrückt. Denn im Ubrigen empfiehlt sich die Sonderung schon deshalb, weil bis auf den heutigen Tag eine gewisse Arbeitsteilung unter den Forschern in sofern besteht, als mykologische und lichenologische Specialkenntnisse sich nur selten in einer Person vereinigt finden. So können beide Gebiete auch nach wie vor gesondert neben einander bestehen, natürlich die Lichenologie stets in engerer Verbindung mit den Resultaten mycologischer Forschung. . . . Schliesslich ist doch Uebersichtlichkeit für den Systematiker, besonders wo es sich wie hier, um ein Specialgebiet handelt, wichtiger als eine allzu puristische Systematik, ausserdem schwanken ja auch in vielen Fällen die Auffassungen über manche phylogenetischen Zusammenhänge noch sehr stark.

Quotation 23

It seems to me most practical to classify the Ascolichenes as a group of the Ascomycetes and the Basidiolichenes, as a group of the Basidiomycetes. A further distribution of the Ascolichenes among the families and genera of the Ascomycetes I regard impracticable for the present. The present classification of the Ascomycetes is quite antiquated and artificial, and surely does not express the natural relationships. Accurate comparative developmental investigations of very many Ascomycetes must first give the material for a new grouping and a fairly natural system of the Ascomycetes. Perhaps it will then also be possible to distribute the lichens among these, but it is also possible—and it seems to me even probable—that it will appear that the families now grouped together as Ascolichenes constitute a reasonably distinct, special family—leaving out of consideration their physiological behavior, symbiosis, etc. *Morphologist*, 2, 4.*

Quotation 24

The individual lichen plant is a specific organism, as capable of specific recognition and description as any other plant species. It is entirely different in structure and physiology from either component alone (*e. g.*, cortical layers, etc.), and often one component is considered incapable of living without the other. Lichens have developed specific and specialized reproductive bodies (soredia). Lichens exhibit many degrees of union and mutual dependence of the components, forming phylogenetic series. Lichens form a

* Mir scheint es am zweckmässigsten, die Ascolichenes als eine Gruppe der Ascomyceten und die Basidiolichenes als eine Gruppe der Basidiomyceten aufzuführen. Eine weitere Aufteilung der Ascolichenes unter die Familien und Gattungen der Ascomyceten halte ich zur Zeit noch für nicht möglich. Die heutige Systematik der Ascomyceten ist eine durchaus veraltete und künstliche, entspricht sicher nicht der natürlichen Verwandtschaft. Genaue, vergleichend entwicklungsgeschichtliche Untersuchungen sehr vieler Ascomyceten müssen erst das Material für eine neue Gruppierung und ein einigermaßen natürliches System der Ascomyceten ergeben. Vielleicht ist es dann möglich, auch die Ascolichenes mit aufzuteilen, aber es ist auch möglich—and mir sogar sehr wahrscheinlich—dass sich ergeben wird, dass die heute als Ascolichenes zusammengefassten Familien eine ziemlich geschlossene eigene Familie der Ascomyceten bilden—ganz abgesehen von ihrem physiologischen Verhalten, Symbiose, u. dgl.

group with as distinct ordinal and family characters as those found in any other groups of plants. Classification is a means to an end. The most useful ends of classification are: (1) Identification of species described and studied by various persons, (2) association of morphological and physiological ideas concerning various plants into useful units of thought. These ends are most helpfully met for me, by maintaining lichens as an independent group. I take it that the real crux lies in my last point. There is of course no possible phylogenetic relation between Ascolichenes and Basidiolichenes. It becomes finally a choice between the convenience to the student of emphasizing such *difference in origin* or of emphasizing the *many points of resemblance* between all lichens. I prefer the latter. *Morphologist*, 1-, 2 (1^2).

Quotation 25

Had we used strict logic, according to the usual procedure elsewhere in systematic Botany, each independent component of the lichen thallus—algae as well as fungi—would have its allotted place near those organisms with which it appears most closely related. But the needs of the lichen-taxonomist are not satisfied in the least by this arrangement. Also the breaking down of this biological group would be very unfavorable for those investigators who study this interesting group, the lichens, in their anatomical, physiological or geographical relations. Because of these considerations I answer your questions as follows: (1) Yes. (2) The lichens should be maintained as a special, biological class. To complete the fungus-system, the genera of the lichen-fungi should, at least, be mentioned among the orders of the fungi. *Biologist*, 2, 8, a- (1^{2-8}).

* Verfährt man streng logisch, nach den sonst in der Systematik üblichen Gepflogenheiten, so hat selbstverständlich jede Komponente des Flechtenthallus—Algae wie Pilz—ihren im System anzuweisenden Platz neben denjenigen Organismen, mit denen sie am nächsten verwandt erscheint. Damit ist aber den Bedürfnissen des Flechtensystematikers nicht im geringsten genügt. Auch für diejenigen Forscher, welche die so interessante Gruppe der Flechten in anatomischer, physiologischer, geographischer Beziehung studieren, wäre die Auflösung dieser biologischen Gruppe sehr unvorteilhaft. Auf Grund dieser Erwägungen beantwortete ich Ihre Fragen folgendermassen: (1) Ja. (2) Die Flechten sind als besondere biologische Klasse aufrecht zu erhalten. Zur vervollständigung des Pilzsystems sind die Gattungen der Flechtenpilze bei den Ordnungen der Pilze wenigstens zu erwähnen.

Quotation 26

Theoretically, and as a matter of pure science, I have no doubt that lichens are fungi. Classification, however, is not a pure science but an applied science. I understand your question to refer to classification for use in systematic work. Up to the present time our systematic knowledge of lichens, with the exception noted below, has come from lichenologists proper. Of course some men have written on both fungi and lichens (*e. g.*, Nylander, who wrote also on Pezizae), but they in the one case, wrote as mycologists; in the other, as lichenologists. In all probability for an indefinite time to come descriptive work in lichens will continue to be in the hands of those who are lichenologists in the strict sense. The mere fact that the gymnocarpic lichens, for instance, are really Discomycetes is no reason why their study should be turned over to those who are specialists in the discomycetous fungi. Practically it is better that we should still continue to regard lichens as a distinct group to be studied by specialists as far as their systematic study is concerned. It is, however, true that lichens and fungi overlap in some cases. Take *Calicium* for instance. Some have gonidia and some do not, therefore, some are lichens and some are fungi. My opinion is that, considering the similar structure of the fruit, whether gonidia are present or not, genera like *Calicium* should be treated as a whole and not split up into fungi and lichens and treated fragmentally. One notices how in Engler and Prantl some genera have been overlooked for the reason that in the part on lichens they were assumed to be fungi and in that on fungi, to be lichens. There are therefore, a few genera with regard to which it may be doubtful whether they should be treated exclusively by lichenologists or not, but that does not affect materially the general question. *Mycologist*, 2, 14, a- (1²⁻¹⁴).

Quotation 27

While I am ready to admit that theoretically the lichens should be included perhaps among the fungi, practically I think they should be regarded as a separate group. The lichens make up such a large group which is so different from all groups of fungi

that they are usually and most conveniently studied by themselves; a study which is certainly sufficient for the life work of any one man. The lichens always appealed to me as being a group comparable systematically to the diatoms or bacteria. That is to say for all practical purposes groups standing off by themselves and best considered by themselves, whatever views one may hold regarding their theoretical relationships. *Mycologist*, 2, 10, a- (1^{2-10}).

Quotation 28

It is practical to treat the lichens as a special class and besides to place under the fungi all those fungi which appear combined with algae as lichens, but also appear without algae as free fungi. We do the same with the algae. If any one wishes to place the lichens under the fungi, there is nothing to say against it. The question is not a scientific one, but a purely practical one. The main point is to learn to know the lichens better and better in all respects. How one wishes to classify them afterwards is a tolerably indifferent matter. It is practical to retain a special division as lichens because we already have so large a lichen literature and such large lichen herbaria, and because most lichens are clearly characterized as such. *Mycologist*, *Physiologist*, 2, 12, 13, a- ($1^{2-12-13}$).*

Quotation 29

From what I know of the Lichens I should be strongly inclined to regard them as having their proper taxonomic position among the Fungi, and they ought to be distributed according to the relationships indicated by the fungal characters. It seems to

* Es ist praktisch, die Lichenen als besondere Classe zu behandeln, und ausserdem alle jene Pilze, welche mit Algen verbunden als Flechten, aber auch ohne Algen als freie Pilze vorkommen, ausserdem unter den Pilzen aufzuzählen. Mit den Algen macht man es ja auch so. Wenn Jemand die Lichenen unter den Pilzen aufzählen will, so ist auch nichts dagegen zu sagen. Die Frage ist keine wissenschaftliche, sondern eine rein practische. Die Hauptsache ist, die lichenen in jeder Hinsicht immer besser kennen zu lernen. Wie man sie nachher classificiren will, ist ziemlich gleichgültig. Practisch ist die Beibehaltung einer besonderen Lichenen-Abteilung, weil es eine so grosse Lichenen-literatur und grosse Lichenen-Herbarien bereits giebt, und weil die meisten Lichenen als solche deutlich characterisirt sind.

me that the term lichen rightly understood is more an ecological expression than it is morphological or taxonomic. A fungus and an alga form a peculiar type of association, and we call that association a lichen. Originally the term may have had some morphological foundation, but it has certainly now become so extended that its only significance is that of a special type of association. It is true that the association is often of an exceedingly intimate character involving morphological changes of a fundamental nature, but this is true of associations everywhere. There appears to me no more reason to treat the lichens as a distinct taxonomic group than to separate out the plants of the salt marsh because they are Halophytes. The Lichens represent a highly specialized ecological group, but still ecological and not morphological and by no means taxonomic. According to the biological conceptions of to-day taxonomy is the attempt to express in diagrammatic form the phylogenetic relationships of the organic world. To constitute the Lichens a distinct taxonomic group would be a violation of our present conceptions, for there is no reason to believe that the lichens as such have sprung from a common ancestral type. The taxonomy of these plants ought to be built upon the fungal rather than the algal phylogeny. For the algal portion, I believe in all cases, can and does maintain an independent existence, and as autonomous organisms have received their proper taxonomic treatment. Moreover the algal portion undergoes little morphological modification by reason of the lichen association, and hence their separate treatment in this way will not introduce confusion. The fungal portion on the other hand has in most instances undergone profound modification by reason of the association, and many of them are unable to maintain an existence separate from the alga. For this reason the fungus is always determinative of the association and the taxonomic classification must express the fungal relationship. In some instances there is undoubtedly a true lichen phylogeny, that is, forms have arisen by modification of a primitive lichen type. These would constitute genera and perhaps families all having the lichen habit, but this would not affect the general principle that ought to control the classification of these plants. I am aware that the argument offered applies in considerable degree

also to the distinction maintained between Algae and Fungi, and I do not believe that the term fungus as now used has any true taxonomic significance. The only argument I see that justifies the present retention of the Subphyllum or Series of the Fungi is that our knowledge of the phylogeny of these forms is inadequate to form a basis for a proper taxonomic classification. The Fungi Imperfecti is another case in point where the situation is more clearly perceived and is usually rightly understood. All of these cases must be regarded as temporary expedients resorted to for convenience and rendered necessary by our ignorance rather than by our knowledge. In the case of the Lichens I suppose this necessity is not now so urgent as it has been and that it is possible to approximate a correct grouping of these forms with their proper fungal relatives. If this be true, and the Lichenologist must answer that question, then we are not justified in maintaining the Lichens as a distinct class. It may be argued that the present grouping is convenient for study and should be retained. This is a return to the Linnaean system and if it were distinctly understood that such classification is only an arbitrary filing system for ready reference it might be admitted, but taxonomy stands for the representation of a deep lying biological principal and no amount of convenience justifies us in misrepresenting the truth. *Mycologist*, a.

Quotation 30

If, as I believe, it is generally agreed by taxonomists, the chief aim of taxonomy is to discover the phylogenetic relationships of plants, and group them as nearly as possible in accordance with such relationships, it is difficult to see how the lichens could be maintained as a distinct group of plants. To treat the lichens as a separate class, necessitates grouping together not only ascomycetous fungi belonging to the great groups Discomycetes and Pyrenomycetes, but also basidiomycetous fungi. Another fact furnishing the strongest evidence perhaps bearing upon the true relationship of the lichens, is the existence of genera and species having so slight an association or connection with algae as to make it difficult for lichenologists to determine whether they should be called plain pyrenomycetous or discomycetous fungi or

should be classified as lichens. Grouping and associating lichens with their nearest relatives among the fungi would also facilitate the study of their relationships and tend to bring about a better understanding of both. *Mycologist, Pathologist, a.*

Quotation 31

The fungi are fungi and the algae are algae. The present method consists simply in classifying colonies. This may be useful as an artificial method of recognizing the fungi and algae concerned, but it is scarcely a natural classification of organisms. The fungus part should be distributed among the fungi and the algae among the algae. *Morphologist, Systematist, a.*

Quotation 32

The lichens should be distributed among the fungi from the theoretical point of view. The lichens are the results of the symbiosis of algae and fungi, just comparable to that of tubercle-bacteria to the Leguminosae. The lichens cannot be considered as a distinct class, for the same reason that we cannot consider the Leguminosae with tubercles to be a distinct class from those without tubercles. *Anatomist, Physiologist, a.*

Quotation 33

I assume that classification is good only in so far as it reflects phylogeny. Since I am convinced that Verrucarias came from black fungi and Lecideas from cup fungi, for example, there is nothing left for me to do but take these out of the common group lichens, and place them as near the ancestral forms as possible. Naturally this connection is even more evident in hymenolichens, which make the usual grouping of lichens still more artificial. To me, the lichen presents a particular food-habit among fungi, just as fungi do among plants generally, and I would no more place so-called pyreno-, disco- and hymeno-lichens together than bacteria, molds, mushrooms, dodders, etc. *Ecologist, Mycologist, a.*

Quotation 34

Lichens should be distributed among the fungi as rapidly as their relationships are pretty clearly made out. Among my reasons for such distribution are the following: (a) An arrangement of plants (classification) should represent real relationship. (b) We now know enough regarding the affinities of the fungi concerned to enable us to treat them as parasitic fungi, and therefore to give them place among fungus genera and families. (c) To maintain the lichens as a separate "class" of plants is distinctly misleading to the botanical student. *Morphologist, a.*

Quotation 35

I am inclined to classify botanists into two groups so far as they hold definite opinions. One group considers classification and nomenclature generally as a means of identifying specimens or things and cares very little about the significance which the system or names may be supposed to exhibit inside the group or to outside forms. Convenience in finding or applying a name largely dominates other considerations. Such botanists are conservative; they want as little change as possible and are usually well satisfied with a crude system if it has once received the sanction of authority and become fairly well known. The second class is eager to make the classification and nomenclature fit into a general scheme of relationship which takes into consideration, not only the convenience of finding and applying names, but also the fullest indication of biological relationship and affinities between members of the group and outside forms as well. I believe such botanists, as a rule, deprecate change on account of the inconvenience which results, quite as much as do the first class, but believe that temporary inconvenience should be endured because of the greater development and clearer understanding which the new system permits. From this crude statement I think you will readily gather that I believe that distributing the lichens with the fungi better illustrates the relationship which these organisms hold to other plants than could be done by maintaining them as a distinct class. *Mycologist; Pathologist, a.*

Quotation 36

Classification should be based on homologies and evolutionary descent. I believe that the Lichens have been derived directly from Fungi. They are a polyphyletic group, hence should be classified in the various groups of fungi. The lichens may be retained as a group for convenience as we speak of fungi and algae, of parasites and saprophytes, etc. But when appearing in a general system they should be distributed among the fungi. There is no question in my mind but that the fungus and the alga parts of a lichen are distinct entities. The fungus spores do not produce algal cells nor the algal cells hyphae. The lichens show more definite relationship to certain groups of fungi than to each other. *Morphologist*, a, 2- (1^a).

Quotation 37

For availability in a large library and herbarium devoted to the whole field of botany, publications on lichens and specimens of lichens are almost of necessity treated as representing a distinct group of thallophytes, because the bulk of taxonomic literature referring to them shows this line of cleavage. Nevertheless, if I were a lichen specialist, with a library and collection devoted mainly to thallophytes and largely to lichens, I should arrange both library and herbarium with reference to the proper position of the different genera in a rational classification of plants as a whole,—unless, indeed, my personal convenience in reference dictated a continuation of the old arrangement, in which case I should follow it for convenience' sake, on the same line of argument that leads one man to alphabetize the genera of a family or the species of a genus, or another man to arrange them both in phylogenetic sequence in his collection. From my limited knowledge of lichens, I should feel disposed, if entering on their study, to treat them in my publications as part of the larger group, unless I found that so made up my publications were certain to fail to find incorporation in the literature of lichens in libraries,—when I might once more bend purely theoretical considerations to those more directly practical in securing the end for which I was publishing. *Systematist*, a, 1-, 12-?, (1^a?) (1^a).

Quotation 38

With respect to their hyphae and their fruiting bodies, the lichens show the same development and the same structure as the ascomycetous fungi. The lichens differ from the Ascomycetes only through their living with algae. Completely similar Ascomycetes without Algae have been shown to exist, for instance, among the Patellariaceae, the Verrucariaceae, etc. Very many Ascomycetes have variously constructed stromata. The lichen-thallus appears in its diversity, corresponding to the stromata of the Ascomycetes, through the various algal colonies living and growing within it, and through the condition of living and nourishing of this stroma thereby induced. Very frequent parallelism of the Ascomycetes and lichens is proven, and a *distribution of the lichens among the Ascomycetes is possible and admissible*. *Mycologist*, a, 1- (1^a).*

Quotation 39

I do not think lichens could be maintained as a distinct class as the term class is understood in taxonomy. In a natural system of plants, I believe, they should be associated with the fungi according to structural characters. It might, however, be very convenient to treat of them separately from the fungi as lichens. Their relations with the algae with the peculiar structure they form rather make them, as a whole, of special interest apart from other groups or associations of plants. For this reason certain persons have interested themselves in the lichens just as some interest themselves in the parasitic fungi rather than the fungi as a whole. There will probably always be an interest and necessity

* Die Lichenes zeigen in Bezug auf ihre Hyphen und ihre fruchtbildenden Organe die gleiche Entwicklung und die gleiche Ausbildung mit den Ascomyceten der Fungi. Die Lichenes unterscheiden sich von den Ascomyceten nur durch ihr Zusammenleben mit Algen, völlig gleiche Ascomyceten ohne Algen sind, z. B. bei den Patellariaceen, Verrucariaceen, etc. erwiesen. Zahlreichste Ascomyceten haben verschieden gebildete Stromata. Der Flechten-Thallus in seiner Mannigfaltigkeit entsteht, als dem Stroma der Ascomyceten entsprechend, durch die verschiedenen in ihm lebenden und gedeihenden Algen-Colonien und die dadurch veranlasste Lebens- und Ernährungsweise dieses Stroma. Vielfachste Parallelität der Ascomyceten und Lichenen ist erwiesen, eine Aufteilung der Lichenes unter die Ascomyceten möglich und statthaft.

for treating the parasitic fungi separately from the other fungi. So that we have and will have, probably, courses on parasitic fungi, books on parasitic fungi and exsiccata of parasitic fungi, etc. It seems to me the treatment of the lichens in books and the study of them by those interested in them occupies very much the same relation, as a whole, as the study and treatment of the parasitic fungi. *Mycologist, Morphologist, a, 2- (1^a)*.

Quotation 40

In a strictly scientific classification, the lichens must be placed under the fungi; the class lichens, as an independent group, must therefore be abandoned. However, these plants may, for the sake of practical combinations, be segregated as a separate group of fungi, as the phytopathologists do respecting the parasitic fungi, in that they consider these artificially separated from other fungi. The works of Schneider, Pierce, my own researches, . . . serve as the foundation for my opinion. It follows from all of these works, that the lichens represent fungi which live parasitically on algae. *Lichenist, a, 2- (1^a)**

Quotation 41

It seems plain to me that the lichens must be abandoned as a special systematic class. 1. Because they represent no uniform organisms. 2. Because they are not a homogeneous group; for, as is well known, various classes of fungi on the one side and of algae on the other side may take part in their formation. Lichens are to be considered only as a biological group, somewhat as the plants with mycorrhiza or the animals with Zoochlorelae and show among themselves greater systematic differentiation than for instance the insect inhabiting plants or the epiphytes. But who

* Bei einer streng wissenschaftlichen Klassifikation, müssen die Flechten unter den Pilzen plaziert werden; die Klasse der Flechten, als selbständige Gruppe, muss daher kassiert werden. Jedoch können dieselben, wegen praktischer Kombinationen, als eine separate Gruppe von Pilzen ausgeschieden werden, wie dies z. B. die Phytopathologen bezüglich der parasitischen Pilze tun, indem sie dieselben künstlich von den anderen Pilzen abgesondert betrachten. Als Grundlage zu dieser meiner Meinung dienen die Arbeiten Schneider's, Pierce's, meine eigene Untersuchungen. . . . Aus allen diesen Arbeiten folgt, dass die Flechten Pilze darstellen, die auf Algen parasitieren.

would think of grouping these last together with their hosts as a systematic class? In spite of this it may seem best under certain circumstances to maintain the old arrangement for floristic or ecologic purposes, but never for systematic purposes. *Physiologist*, a, 8-. (1^a).*

Quotation 42

Theoretically I consider it absolutely correct to distribute the lichens among the fungi, and for the following reasons. The classification of fungi is really based in the main upon the morphological relationships of the reproductive areas and in the lichens also these relationships surely have greater importance in classification than the form-relationships of the thallus. Since the structure and development of the fruits of lichens correspond to that of the Thelephoraceae, the Pyrenomycetes, the Hysteriaceae, the Phacidiaceae, the Pezizaceae, etc., I see no reason why one should not distribute the lichens into these groups. Of course it is not impossible that there will be small groups which will be represented only by lichens, just as there will also be many groups of fungi that are represented by no lichens. So lies the matter in theory. But in practice, for instance for presentation in lectures or in text-books, it will always remain clearer, if one treats the lichens as a whole on account of their peculiar and uniform biological relationships. *Mycologist*, b, 2-. (1^b).†

*Es scheint mir klar, dass die Flechten als besondere systematische Klasse gestrichen werden müssen. 1. Weil sie keine einheitlichen Organismen darstellen. 2. Weil sie auch unter sich nicht gleichartig sind; denn bekanntlich können an ihrer Bildung verschiedene Klassen von Pilzen einerseits und von Algen anderseits teilnehmen. Sie sind also nur als biologische Gruppe aufzufassen, etwa wie die Pflanzen mit Mikorrhizen oder die Tiere mit Zoochlorellen und zeigen unter sich grössere systematische Differenzen als z. B. die Insektinoren oder die Epiphyten. Wer aber würde gar daran denken, letztere mit ihren Wirten zu einer systematischen Klasse zusammenzufassen? Trotzdem kann es sich unter Umständen als zweckmässig erweisen für floristische oder ökologische Zwecke, nie aber für systematische, die alte Einteilung aufrecht zu erhalten.

† Theoretisch halte ich es unbedingt für das Richtige, die Flechten unter die Pilze zu vertheilen und zwar aus folgenden Gründen. Die Klassifikation der Pilze gründet sich doch eigentlich im ersten Sinne auf die morphologischen Verhältnisse der Fruchtkörper und auch bei den Flechten kommen diesen Verhältnissen sicher eine grössere Bedeutung für die Klassifikation zu, als den

SUMMARY AND CONCLUSIONS

1. About 83 per cent. or five sixths of 115 botanists believe that the lichens should be maintained as a distinct group of plants.

2. About 17 per cent. or one sixth of 115 botanists believe that lichens should be distributed among other fungi to the exclusion of the group Lichenes.

3. Of the 83 per cent. who favor maintaining the group Lichenes about 12 per cent. think that distribution is admissible.

4. So about 26 per cent. of the 115 botanists think distribution either desirable or admissible.

5. Lichenists stand almost universally for maintaining Lichenes because a natural group.

6. Yet seventeen (17) botanists other than lichenists, or about 20 per cent. of other botanists, favor distribution of lichens, while about 80 per cent. of botanists other than lichenists favor maintaining the group. So the views of lichenists have not greatly influenced the results as given in one (1) and two (2) above.

7. Europeans are more favorable to maintaining lichens as a natural group of plants than are Americans.

8. The figures in the first table show that, lichenists excepted, convenience has had greater weight than naturalness of the group in causing so large a per cent. of botanists to favor maintenance.

9. Forty (40) botanists favored maintaining Lichenes because a natural group and 22 favored distributing these plants because not a natural group. So leaving out of account every consideration except naturalness, more than half as many favor distribution as there are in favor of maintenance.

10. Leaving lichenists out of the consideration, 25 other

Formverhältnissen der Thallus. Da nun um Bau und Entwicklung der Flechtenfruchtkörper ganz demjenigen der Thelephoraceen, Pyrenomyceten, Hysteriaceen, Phacidaceen, Pezizaceen, etc. entsprechen, so sehe ich keinen Grund ein weshalb man die Flechten nicht auch in diese Gruppen vertheilen sollte. Dabei ist natürlich nicht ausgeschlossen, dass es dann auch kleinere Gruppen geben wird, die nur durch Flechten vertreten sein werden, ebenso wie es ja auch viele Gruppen von Pilzen gibt, die durch keine Lichenen repraesentirt sind. So liegen die Dinge in der Theorie. In Praxi aber, z. B. in der Darstellung für die Vorlesungen oder in der Lehrbüchern wird es doch immer anschaulicher bleiben, wenn man die Flechten für sich im Zusammenhange behandelt wegen ihrer eigenartigen und einheitlichen biologische Verhältnissen.

botanists favor maintaining lichens because a natural group, and 17 favor distributing lichens because not a natural group.

11. Botanists have plainly favored maintaining the group Lichenes, even as a natural group, but about as much for the sake of convenience in study.

12. There has been a considerable growth of opinion in favor of the distribution of lichens. This change of opinion has occurred since the announcement of Schwendener's views in 1868, and probably most of it very recently. Lichens have been distributed in writings by Bessey and Clements and in Nebraska and California lists of lichens, but without statement of reason for such distribution. The first careful arguments published in favor of distributing lichens appear in this paper.

The writer wishes to thank the botanists whose names appear below for replying to the circular letter.

- | | |
|--|---|
| Arthur, J. C., Mycologist, Pathologist, Indiana. | Clinton, G. P., Mycologist, Pathologist, Connecticut. |
| Atkinson, Geo. F., Mycologist, Morphologist, New York. | Conard, R. S., Morphologist, Iowa. |
| Banker, Howard J., Mycologist, Indiana. | Coulter, John M., Morphologist, Illinois. |
| Barnes, C. R., Physiologist, Illinois. | Coville, Frederick V., Systematist, Washington, D. C. |
| Baur, Erwin, Morphologist, Germany. | Curtis, C. C., Morphologist, Physiologist, New York. |
| Bennett, A., Systematist, England. | Dangeard, P. A., Morphologist, France. |
| Bessey, C. E., Morphologist, Nebraska. | Darbshire, Otto V., Cryptogamist, Lichenist (?), England. |
| Bitter, Georg, Lichenist, Germany. | Davis, B. M., Cryptogamist, Morphologist, Massachusetts. |
| Blackman, V. H., Mycologist, England. | Durand, E. J., Mycologist, Missouri. |
| Bower, F. O., Morphologist, Scotland. | Earle, F. J., Mycologist, Pathologist, Cuba. |
| Bresadola, G., Mycologist, Austria. | Elenkin, A., Lichenist, Russia. |
| Britton, N. L., Systematist, New York. | Engler, A., Morphologist, Germany. |
| Brooks, F. T., Mycologist, England. | Evans, Alexander W., Bryologist, Connecticut. |
| Burrill, T. J., Mycologist, Pathologist, Illinois. | Famintzyn, A. S., Physiologist, Russia. |
| Burt, E. A., Mycologist, Vermont. | Farlow, W. G., Mycologist, Pathologist, Massachusetts. |
| Calkins, W. W., Lichenist, Illinois. | Farmer, J. B., Morphologist, England. |
| Campbell, D. H., Morphologist, California. | Fischer, Ed., Mycologist, Switzerland. |
| Chamberlain, Chas. J., Morphologist, Illinois. | Freeman, E. M., Mycologist, Pathologist, Minnesota. |
| Cheel, Edwin, Lichenist, Australia. | |
| Chodat, R., Miscellaneous, Switzerland. | |
| Clements, Frederic E., Ecologist, Mycologist, Minnesota. | |

- Fries, Th. M., Lichenist, Miscellaneous, Sweden.
- Frye, T. C., Morphologist, Systematist, Washington.
- Fünfstück, M., Lichenist, Germany.
- Galløe, O., Lichenist, Denmark.
- Ganong, W. F., Physiologist, Massachusetts.
- Goebel, K. E., Morphologist, Germany.
- Hackel, E., Agrostologist, Austria.
- Harper, R. A., Morphologist, Mycologist, Wisconsin.
- Harshberger, John W., Ecologist, Mycologist, Pennsylvania.
- Hasse, H. E., Lichenist, California.
- Hedlund, T., Lichenist, Sweden.
- Herre, A. C., Lichenist, California.
- Hitchcock, A. S., Agrostologist, Washington, D. C.
- Howe, R. Heber, Jr., Lichenist, Massachusetts.
- Hue, A. M., Lichenist, France.
- Ikeno, S., Anatomist, Physiologist, Japan.
- Johnson, D. S., Morphologist, Maryland.
- Jones, L. R., Mycologist, Pathologist, Wisconsin.
- Jost, L., Miscellaneous, Germany.
- Klebahn, H., Mycologist, Germany.
- Kny, L., Anatomist, Physiologist, Germany.
- Lindau, G., Mycologist, Lichenist, Germany.
- Lloyd, Francis E., Morphologist, Physiologist, Alabama.
- Lotsy, J. P., Morphologist, Holland.
- Macbride, Thos. H., Mycologist, Iowa.
- MacDougal, D. T., Physiologist, Arizona.
- Macoun, John, Cryptogamist, Canada.
- Magnus, Paul, Mycologist, Physiologist, Germany.
- Maiden, J. H., Systematist, Australia.
- Massalongo, C., Miscellaneous, Italy.
- Mattirolo, O., Anatomist, Mycologist, Italy.
- Merrill, G. K., Lichenist, Maine.
- Miller, Mary F., Lichenist, Washington, D. C.
- Möller, A., Mycologist, Physiologist, Germany.
- Moore, George T., Pathologist, Cryptogamist, Missouri.
- Mottier, D. M., Morphologist, Indiana.
- Murrill, W. A., Mycologist, New York.
- Nölle, E., Systematist, Germany.
- Olive, E. W., Morphologist, South Dakota.
- Pammel, L. H., Morphologist, Mycologist, Iowa.
- Patouillard, N., Mycologist, France.
- Peck, Chas. H., Mycologist, New York.
- Peirce, George J., Physiologist, California.
- Penhallow, D. P., Morphologist, Canada.
- Penzig, O., Systematist, Italy.
- Prairie, D., Systematist, Phytogeographer, England.
- Pringsheim, Ernst G., Physiologist, Germany.
- Rehm, H., Mycologist, Germany.
- Reinke, J., Physiologist, Lichenist (?), Germany.
- Ricker, P. L., Mycologist, Washington, D. C.
- Riddle, Lincoln W., Lichenist, Massachusetts.
- Romell, L., Mycologist, Sweden.
- Rose, J. N., Systematist, Washington, D. C.
- Rostrup, Ove, Mycologist, Denmark.
- Saccardo, P. A., Mycologist, Italy.
- Schaffner, John H., Morphologist, Ohio.
- Schneider, Albert, Lichenist, Medical Botany, California.
- Schröter, C., Systematist, Switzerland.
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